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COST/BENEFIT TRADEOFFS FOR REDUCING THE ENERGY CONSUMPTION OF THE COMMERCIAL AIR TRANSPORTATION SYSTEM

FINAL REPORT

VOLUME II: MARKET AND ECONOMIC ANALYSES

JUNE 1976

Prepared Under Contract NAS2-8618
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AMES RESEARCH CENTER

DOUGLAS AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION
Long Beach, California

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COST/BENEFIT TRADEOFFS FOR REDUCING THE ENERGY CONSUMPTION OF THE COMMERCIAL AIR TRANSPORTATION SYSTEM

FINAL REPORT

Volume II

Market and Economic Analyses

by

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PREFACE

This report was prepared by the Douglas Aircraft Company, McDonnell Douglas Corporation, under NASA Contract NAS2-8618 for a study of the "Cost/Benefit Tradeoffs for Reducing the Energy Consumption of the Commercial Air Transportation System." The study, hereafter referred to as the RECAT Study (Reduced Energy for Commercial Air Transportation), was performed from November 5, 1974 to June 30, 1976.

The NASA Technical Monitor for the RECAT Study was Louis J. Williams, Research Aircraft Technology Office, Ames Research Center, Moffett Field, California.

The Douglas Study Team consisted of Emmett F. Kraus, responsible for Technical Analyses, assisted by Melvin A. Sousa, responsible for Turboprop Aircraft Analysis; and June C. Van Abkoude, responsible for Market and Economic Analyses, assisted by Clayton R. Sturdevant.

Appreciation for their cooperation and contribution is extended to the RECAT Study co-contractors: Lockheed-California Company, United Air Lines and United Technologies Research Center. Appreciation is also extended to the Hamilton Standard Division of United Technologies Corporation for assistance in preparation of propfan propulsion data.

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SYMBOLS AND ABBREVIATIONS

AA	American Airlines
A/C	Aircraft
ALLOC	Allocation
ALPA	Air Line Pilots Association
ASM	Available Seat-Mile
ASNM	Available Seat-Nautical Mile
ATA	Air Transport Association
ATC	Air Traffic Control
ATL	Atlantic Operations
AVG	Average
BLK	Block
BN	Braniff International
BTU	British Thermal Unit
CAB	Civil Aeronautics Board
CO	Continental Air Lines
CONSER	Conserving
CUM	Cumulative
DAC	Douglas Aircraft Company
DERIV	Derivative
DL	Delta Air Lines
DOC	Direct Operating Cost
DOC_{15}	Optimization Parameter: Minimum DOC @ 15 Cents per Gallon Fuel
DOC_{30}	Optimization Parameter: Minimum DOC @ 30 Cents per Gallon Fuel
DOC_{60}	Optimization Parameter: Minimum DOC @ 60 Cents per Gallon Fuel
Δ	Incremental Parameter Change
EA	Eastern Air Lines
EXIST	Existing
FAA	Federal Aviation Administration
FLT	Flight
FT	Feet
4-D RNAV	Four-Dimensional Area Navigation
GAL	Gallon
HR	Hour

HUBS	Hub-Constrained Airports
IATA	International Air Transport Association
IMPR	Improved
INC	Increased
IOC	Indirect Operating Cost
LAT	Latin American Operations
LB	Pound
L.F.	Load Factor
M	Mach Number
MAX	Maximum
MF	Optimization Parameter: Minimum Fuel
MIN	Minimum
MOD	Aircraft Modification or Retrofit Option
NA	National Airlines
NASA	National Aeronautics and Space Administration
NM	Nautical Mile
NO.	Number
NW	Northwest Airlines
N80	New Near-Term Aircraft: NASA Specification, 1980 Introduction Date
OAG	Official Airline Guide
OEW	Operational Empty Weight
OPERS	Operations
PAA	Pan American World Airways
PAC	Pacific Operations
PROP	Propeller
PSGR	Passenger
P&WA	Pratt and Whitney Aircraft
RAND	The Rand Corporation
RECAT	Reduced Energy for Commercial Air Transportation
RPM	Revenue Passenger-Mile
RPNM	Revenue Passenger-Nautical Mile
SCW	Supercritical Wing
SLSD	Sea Level-Standard Day
ST.MI.	Statute Mile

TOC	Total Operating Cost
TOGW	Takeoff Gross Weight
TSLS	Thrust-Sea Level Static
TW	Trans World Airlines
UAL	United Air Lines
UTRC	United Technologies Research Center
WA	Western Air Lines
WTD	Weighted
YR	Year

HUB-CONSTRAINED AIRPORTS:

ATL	Hartsfield-Atlanta Int'l Airport - Atlanta, Georgia
BOS	Logan Int'l Airport - Boston, Massachusetts
CLE	Hopkins Int'l Airport - Cleveland, Ohio
DCA	Washington National Airport - Washington, D.C.
DEN	Stapleton Int'l Airport - Denver, Colorado
DTW	Detroit Metropolitan Airport - Detroit, Michigan
EWR	Newark Municipal Airport - Newark, New Jersey
JFK	John F. Kennedy Int'l Airport - Jamaica, New York
LAX	Los Angeles Int'l Airport - Los Angeles, California
LGA	LaGuardia Int'l Airport - Flushing, New York
MIA	Miami Int'l Airport - Miami, Florida
ORD	O'Hare Int'l Airport - Chicago, Illinois
PIT	Greater Pittsburgh Int'l Airport - Pittsburgh, Pennsylvania
SFO	San Francisco Int'l Airport - San Francisco, California

UNITS CONVERSION TABLE:

TO CONVERT	MULTIPLY BY
LINEAR:	
Feet to Meters	0.3048
Nautical Miles to Kilometers	1.852
VOLUME:	
Gallons to Liters	3.785
WEIGHT	
Pounds to Kilograms	0.4536

SUMMARY

The purpose of this study was to examine and compare the fuel saving potential and cost effectiveness of numerous operational and technical options proposed for reducing the fuel consumption of the U.S. commercial airline fleet. Another objective was to determine the impact of the most promising fuel conserving options on fuel consumption, passenger demand, operating costs and airline profits when implemented into the U.S. domestic and international airline fleets. Additionally, the potential fuel savings achievable in the U.S. scheduled air transportation system over the forecast period, 1973-1990, was estimated. The study was divided into three parts with each part actually a study in itself.

Part I, the primary study, investigated the means for reducing the jet fuel consumption of the U.S. scheduled airlines in domestic passenger operations. Part II concentrated on the design and examination of two turboprop aircraft as possible fuel conserving derivatives of the DC-9-30. Part III extended the primary study in Part I to include the international operations of the U.S. scheduled carriers.

The final results of the study are being presented in two volumes. Volume I documents the results of the technical analyses, while Volume II presents the results of the market and economic analyses. A summary of the technical analyses conducted for each part of the study is given in Volume I.

Part I: Study of the U.S. Domestic Air Transportation System

The market analysis in Part I began with an investigation of the scheduled airline operations within the U.S. domestic air transportation system and was carried out in two phases. Phase I involved the selection of a study market representative of the domestic system's characteristics, and a projection of the traffic demand in this market from 1973-1990. Phase II concerned the development of alternative fleet forecasts to screen and select the most promising fuel conserving operational and technical options for the U.S. domestic airline fleets during the forecast period. Fleet requirements for and fuel savings from the selected aircraft options in the study market were then projected to the total domestic scheduled system.

The route network selected in Phase I considered only those scheduled services operated with existing Douglas jet equipment by the U.S. domestic trunk and local service airlines within the continental United States. The study market contained approximately 34 percent of the carriers' revenue passenger-miles. The spectrum of diverse equipment types serving this selected market, along with its traffic capacity, distribution characteristics, and levels of service adequately represented the total 1973 trunk and local service airline environment and is expected to be representative of its growth characteristics as well. After the study market was determined, a baseline operating scenario reflecting the actual 1973 operating environment for these carriers was developed, and the traffic demand on the study network was forecast through 1990.

Concurrently, the possibilities for reducing aircraft and system fuel consumption by means of operational changes, retrofit and production modifications, derivative aircraft, and new near-term aircraft were being technically analyzed. Seven baseline aircraft representative of Douglas jet transports in the domestic fleet and the 1973 fleet serving the study market were used as the bases from which to compare the potential fuel savings, and later, the economic and operational viability of the aircraft options under consideration. From the technical analysis, 46 aircraft operational and design options were specified for further evaluation in the study market.

In order to assess the economic viability of each option, consistent aircraft prices were developed and total operating costs were calculated at the three NASA-specified fuel prices of 15 cents, 30 cents, and 60 cents per gallon. The fuel consumption and operating costs of the seven baseline aircraft were used as the references from which to compare the relative improvement in fuel savings and TOC reductions for the 46 aircraft options. As might be expected, as fuel price was increased from 30 cents to 60 cents per gallon, more fuel conserving options became economically attractive.

The selection of the most economically viable aircraft options strictly on the basis of direct and/or total operating costs was inconclusive, primarily because aircraft with unequal capabilities were being compared. They had widely different design ranges as well as seating capacities. Therefore, to realistically evaluate the viability of one aircraft option over another, the economic and operational performance of each aircraft was compared, including its ability to serve a particular market or route as well as maximize system profit.

To select the most promising operational, modification, derivative or all-new aircraft options in terms of their fuel savings and economic viability, alternative fleet forecasts were developed in Phase II of the U.S. domestic study. These fleet forecasts were used to screen the aircraft options against the projected market requirements through 1990. In accomplishing this, alternative operating scenarios were created by varying one or more of the operational constraints assumed in the baseline scenario during the 1973-1990 forecast period. The operational conditions that were varied included changes in fuel availability and price, hub constraints, RPM demand, load factor, and the offering of differing combinations of aircraft options to meet subsequent aircraft demand. The operational and economic performance of the existing, modified, derivative, and new near-term aircraft options under study were then measured in these simulated operating scenarios. An optimum fleet was selected under each alternative scenario for the 1973-1990 time period as a function of maximum airline profitability.

The results of these fleet forecasts were then compared both economically and operationally. A comparison of the changes in the detailed operational and economic statistics for each fleet forecast, on an annual basis as well as over the entire study period (1973-1990), provided the information necessary to assess the operational and economic viability of the various aircraft options. The criteria used in comparing viability included operating costs, potential airline profit, passenger demand satisfied, fuel saved, as well as the forecasted fleet size and mix.

Out of the possibilities studied for reducing fuel consumption through operational changes, the most promising fuel conserving operational procedures were based upon an improved ATC system assumed available in 1980. With an improved system, direct operating cost savings of between 3 1/2 to 5 percent were achieved generally for the baseline airplanes. The total potential fuel savings from both improved operating procedures and an advanced ATC were over 10 percent, or nine million tons, during the period 1980-1990.

Following the analysis of improved operational procedures, the potential for modifying existing and in-production aircraft to conserve fuel was evaluated. Retrofits to the existing airplanes included general drag reduction items, winglets, and new engines. More extensive modifications to the in-production DC-10 models such as composite secondary structure were also examined. The aerodynamic retrofits studied offered the greatest potential for retrofitting to conserve fuel, and, in fact, some of these aerodynamic modifications are currently being offered on new production DC-10's. This was particularly true for the older DC-8 airplanes which also showed a modest improvement in DOC's. The existing aircraft types retrofitted with new JT8D-209 refan engines achieved reasonable fuel savings, but were uneconomical to operate due to the high cost of the new engines and the airframe modifications needed to install the new refan engines. Possible retrofits involving newer technology high-bypass-ratio engines such as the JT10D and CFM-56 were not considered in this study. The in-production modifications also provided fuel savings, but these savings were not large enough to offset the resulting increase in DOC's, again due to the added cost of the modifications. The three most promising modification options selected by the market provided fuel savings of almost 1 1/2 percent over the forecast period, 1973-1990.

The derivative aircraft types under study proved that it is economically feasible to make extensive modifications to existing aircraft for the purpose of improving seat-mile fuel economy and offered the most promising potential for reducing fuel consumption in the near-term. When the selected derivative options were added to the fleet of existing airplanes and selected mod options, fuel savings improved substantially to 7 percent during 1980-1990, and nearly 8 1/2 percent in 1990 alone, or a savings of over five million tons from 1980-1990. Profits per RPM also increased by over 5 percent during 1980-1990 with the selected derivative options in the fleet.

The all-new 1980 introduction aircraft (N80's) also offered a good potential for economically reducing aircraft fuel consumption, but since their market introduction was timed so close to that of the derivatives, the all-new aircraft could not realize their full potential in the study market by 1990. Even though fuel savings of over 10 percent were achieved from a mixed fleet of selected aircraft options (mods, derivatives, plus N80's) over the 1980-1990 time period, the real promise of the N80's is demonstrated by the mixed fleet fuel savings of 14-15 percent in 1990 alone. It would be appropriate to delay the introduction of the viable N80 aircraft options until 1985-1990, and to measure their fuel saving improvement over the viable derivative aircraft options through the year 2000.

Part II: Economic Analysis of DC-9 Derivative Turboprop Aircraft

Two short/medium range turboprop configurations were designed in Part II to take advantage of recent advances in turboprop technology as a means of reducing aircraft fuel consumption. These two DC-9/B-737 type replacement airplanes were then operationally and economically compared with their turbofan counterparts.

Total flyaway costs of the turboprop airplanes were almost 12 percent higher than for the turbofan aircraft. However, due to fuel savings of between 27 and 33 percent, the turboprops offered DOC savings of 5-6 percent with fuel at 30 cents per gallon and 9-10 percent with fuel at 60 cents per gallon. Possible, as yet undocumented, maintenance benefits for the turboprop airplanes might increase these DOC savings still further. This preliminary investigation showed that there is considerable promise in the fuel saving potential and economic viability of advanced technology turboprops in competition with turbofan aircraft in the air transportation system.

Part III: Study of the U.S. International Air Transportation System

The international operations of the U.S. scheduled airlines were also studied in order to determine the international fleet requirements and anticipated fuel demand for these carriers during the period 1974-1990. The study market included all the city-pairs outside the continental U.S. and Canada presently served by these airlines; and a total of thirteen baseline aircraft were examined as representative of the airplanes in the 1974 U.S. international fleet. The baseline fleet included Douglas, Boeing, and Lockheed airplanes. Several possible long-range derivatives of existing aircraft as well as six all-new near-term aircraft (N80's) were analyzed in terms of their economic viability and potential fuel savings relative to the baseline airplanes.

The market analysis was accomplished in the same manner as for the U.S. domestic study (Part I). The U.S. international scheduled market and its characteristics were carefully reviewed, and a forecast was made of the potential traffic demand in this market from 1974-1990. For the base year, 1974, the actual revenue passenger-miles performed were used. A baseline operational scenario was also developed to reflect the operating environment of the U.S. international carriers during 1974. Next, alternative fleet forecasts were developed to screen the ten potential fuel conserving aircraft options against the projected U.S. international market requirements through 1990. The objective criterion for each fleet forecast was to maximize airline profits through the appropriate choice of offered fuel conserving aircraft options under a particular operating environment. Using this method the operational and economic performance of each existing, derivative, and new near-term aircraft option was measured in the simulated airline operational scenarios on an annual basis as well as over the entire forecast period.

Out of the ten airplanes studied, two were selected as being the most promising in terms of fuel conservation as well as economic and operational viability. These two aircraft were the DC-10-10D, a shortened DC-10-10 configured for 199 seats, and the DC-10-30D2, a stretched DC-10-30 with 327 seats. When the selected derivative options were added to the fleet of existing airplanes, at a fuel price of 30 cents per gallon, profits increased by 6 percent from 1976-1990 and by almost 7 percent from 1980-1990. Fuel savings also improved substantially, amounting to almost 6 percent during 1980-1990 and almost 11 percent in 1990 alone, or a total savings of over 4.6 million tons from 1980-1990.

Not one of the six all-new N80 airplanes studied was really viable or flexible enough to be desired by the market under any of the simulated airline environments studied. When added into the fleet, the selected N80 options increased profits by approximately 1 1/2 percent at a fuel price of 30 cents per gallon, but fuel savings did not improve over that provided by the derivatives.

The conclusions drawn from the entire RECAT Study indicate that in order to maximize fuel savings, the air transportation industry should concentrate on the most viable operational, modification, and derivative options for the near-term, and continue to pursue the research and technology necessary for the most promising new aircraft designs including the turboprop for 1985-1990 introduction.

INTRODUCTION

In late 1973, when jet fuel prices began to increase rapidly and fuel supplies were limited, attention was focused on the air transport industry's need to increase efficiency and conserve fuel. In response, the airlines made immediate adjustments in schedules and operations, while government and industrial organizations pursued efforts to identify the most effective means of reducing present and future transport fuel requirements.

Preliminary studies indicated that changes in aircraft schedules and operations, together with the application of new technologies, could lead to fuel savings of over 50 percent (References 1-10, Volume I). However, the solutions presented were often a mixture of near-term and far-term improvements, and the real costs and effectiveness of these fuel saving possibilities over time were unclear.

In November 1974, the NASA Ames Research Center contracted with Douglas Aircraft Company (DAC), Lockheed-California Company, United Airlines, and United Technologies Research Center to study the relative costs and benefits associated with near-term solutions for Reducing the Energy consumed by U.S. domestic Commercial Air Transportation (RECAT Study). The study was structured to provide interaction among the contractors in order to determine those fuel conserving options that offered the most promise for fuel conservation in the near-term. The study options and their associated costs were reviewed by the airline contractor to assure their realism and suitability for commercial airline use. Using the most promising fuel conserving options, alternative fleet forecasts were developed to establish realistic bounds around the demand for jet fuel in the U.S. domestic system through 1990.

During the course of the study, two new areas of interest developed for potential fuel conservation. The first was a specific examination of advanced turboprop aircraft, while the second was the potential for, as well as the particular problems associated with, fuel conservation for U.S. carriers operating in the international market. In November 1975, the Douglas Aircraft Company was contracted by NASA to study DC-9 derivative turboprop-powered aircraft, and to conduct a preliminary investigation of fuel conservation in the U.S. international market as additional tasks to the primary RECAT Study.

This final report documents the results of the U.S. domestic and international fleet studies as well as the turboprop analysis and is presented in two volumes. Volume I records the technical results: Sections 1.0 through 5.0 contain the technical analyses of the fuel conserving aircraft options studied for use by the U.S. domestic airline fleet; Section 5.0 also presents the technical details of the fuel conserving aircraft options investigated for the U.S. international fleet; Section 6.0 describes the DC-9 derivative turboprop designs studied.

Volume II presents the analyses performed to determine the market suitability and economic viability of the domestic and international fuel conserving options as well as the turboprop aircraft under study. Section 1.0 describes the domestic study market, while Section 2.0 documents the results of the economic analyses of each aircraft option examined for use in the U.S. domestic airline fleets. Section 3.0 presents the fleet forecast results and projected jet fuel demands for the domestic study market as well as the U.S. domestic air transportation system. Results of the market and economic analyses conducted for the U.S. international fleet are recorded in Section 4.0, and the potential economic viability of a DC-9 derivative turboprop is given in Section 5.0.

This report contains U.S. Customary Units. Conversions to International System (SI) Units are presented with the Symbols and Abbreviations.

SECTION 1.0

PHASE I - U.S. DOMESTIC MARKET ANALYSIS

The objective in Phase I was to develop a flexible and realistic demand projection model representative of the markets served by the U.S. domestic scheduled airlines for the study period, 1973-1990. To accomplish this task a route network and baseline operating scenario were defined, and the traffic demand over this study network was then forecast.

Alternative operating scenarios were also established by varying one or more of the baseline operational constraints. During Phase II the impact of changing the constraints such as fuel price, fuel availability, and load factor on traffic demand and fuel consumption was determined from the fleet forecast results. This is documented in Section 3.0.

1.1 DC-Jet Route Network

The route network developed considered only the scheduled services operated with existing Douglas jet equipment by the U.S. trunk and local service carriers within the continental United States. NASA specified 1973 as the initial study year in order to provide a pre-energy crisis reference for the fleet analysis discussed in Section 3.0. The markets served and the daily city-pair operational statistics including departures, available seat-miles, and aircraft types (DC-8, DC-9, DC-10) were determined from the August 1973 Official Airline Guide. August was selected because it represents the peak month of the year for passenger travel. For consistency, the available seat-miles were adjusted by aircraft type to reflect the technical groundrule of a 10/90 split between first class and coach for all seating configurations. Using the CAB's Seasonally Adjusted Data Report for the U.S. Trunks and Pan American, it was determined that the August ASM's represented 9.3 percent of the annual 1973 available seat-miles. Therefore, applying this percentage to the total August ASM's, the DC-Jet route network generated 95.1 billion ASM's in 1973.

1.2 Study Market vs. Total U.S. Domestic Market

The revenue passenger-miles generated by the DC-Jet network represented 34 percent of the U.S. domestic (50 state) trunk and local service carrier's RPM's, 126 billion in 1973. As shown in Figure 1, the traffic levels and distribution with stage length for the study market versus the actual U.S. domestic market were virtually the same.

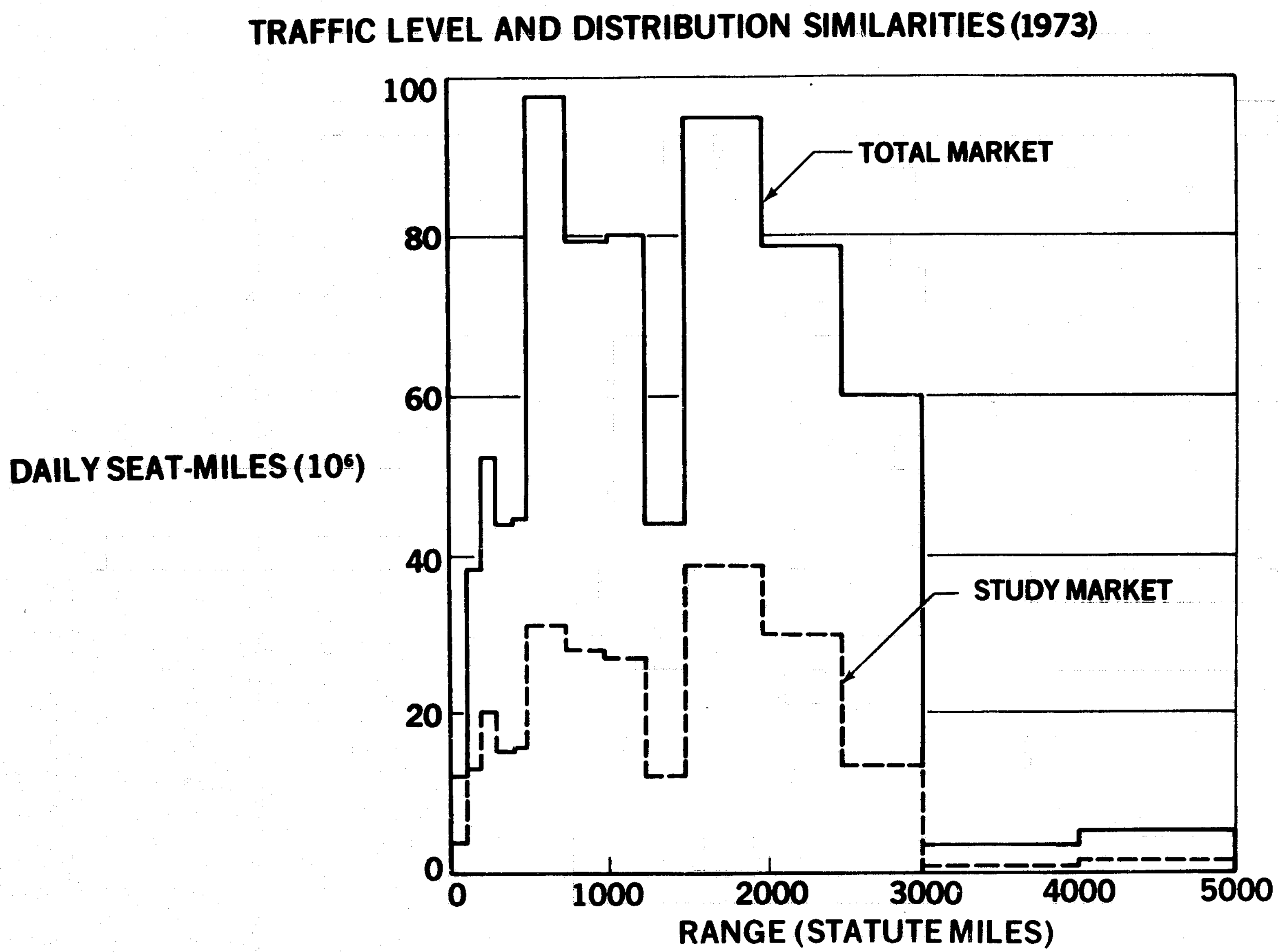


Figure 1. SELECTED STUDY MARKET VS. TOTAL DOMESTIC MARKET

1.3 Study Market Characteristics and Demand Model Development

In analyzing the study market, the distribution of departures and available seat-miles with stage length were compared. The annual departures by range achieved in 1973 over the DC-Jet network are illustrated in Figure 2. Almost 80 percent of the flights were on routes of 600 miles or under while less than 5 percent of the flights were over 1,600 miles, demonstrating the importance of the shorter-haul routes in the network. The DC-9-30 provided 58 percent of all the departures in the study market; 84 percent of which were to other points in the system less than 500 miles away. The DC-10-10 contributed 9 percent of the departures in 1973, 74 percent of these were at ranges greater than 500 miles.

The available seat-miles, at a 10/90 split, performed over this network in 1973 are shown in Figure 3. Approximately 60 percent of the ASM's were generated on routes at or under 1,200 statute miles, while almost 80 percent were flown on routes of 1,800 statute miles or less. In contrast to the departures, this distribution was more heavily concentrated at the longer stage lengths since seat-miles are a direct function of the flight mileage and the number of seats. Aircraft such as the DC-10-10 are not only carrying the most seats, but are also flying over the longer routes. For example, the DC-9-30 contributed 25 percent of the ASM's, but it has only 92 seats and an average stage length of 335 miles (290 NM). The 277 seat DC-10-10 on the other hand generated 38 percent of the ASM's, the vast majority on flights over its average trip length of 1000 statute miles (870 NM).

1.3.1 Stage Length Classes

In order to preserve the importance of the shorter-haul markets in the network, the distribution of departures as a function of range became the primary determinant in establishing the stage length classes necessary for the fleet forecasting model. Stage length classes were used to consolidate similar daily operational statistics of the study market's airport pairs into compatible groups to facilitate computer computation of a large amount of data. Table 1 shows the range classes chosen and the percentage of departures per class and cumulatively. The greatest mileage spread within a class is at the longer ranges. Figure 4 illustrates the 1973 ASM distribution by aircraft type for each stage length class.

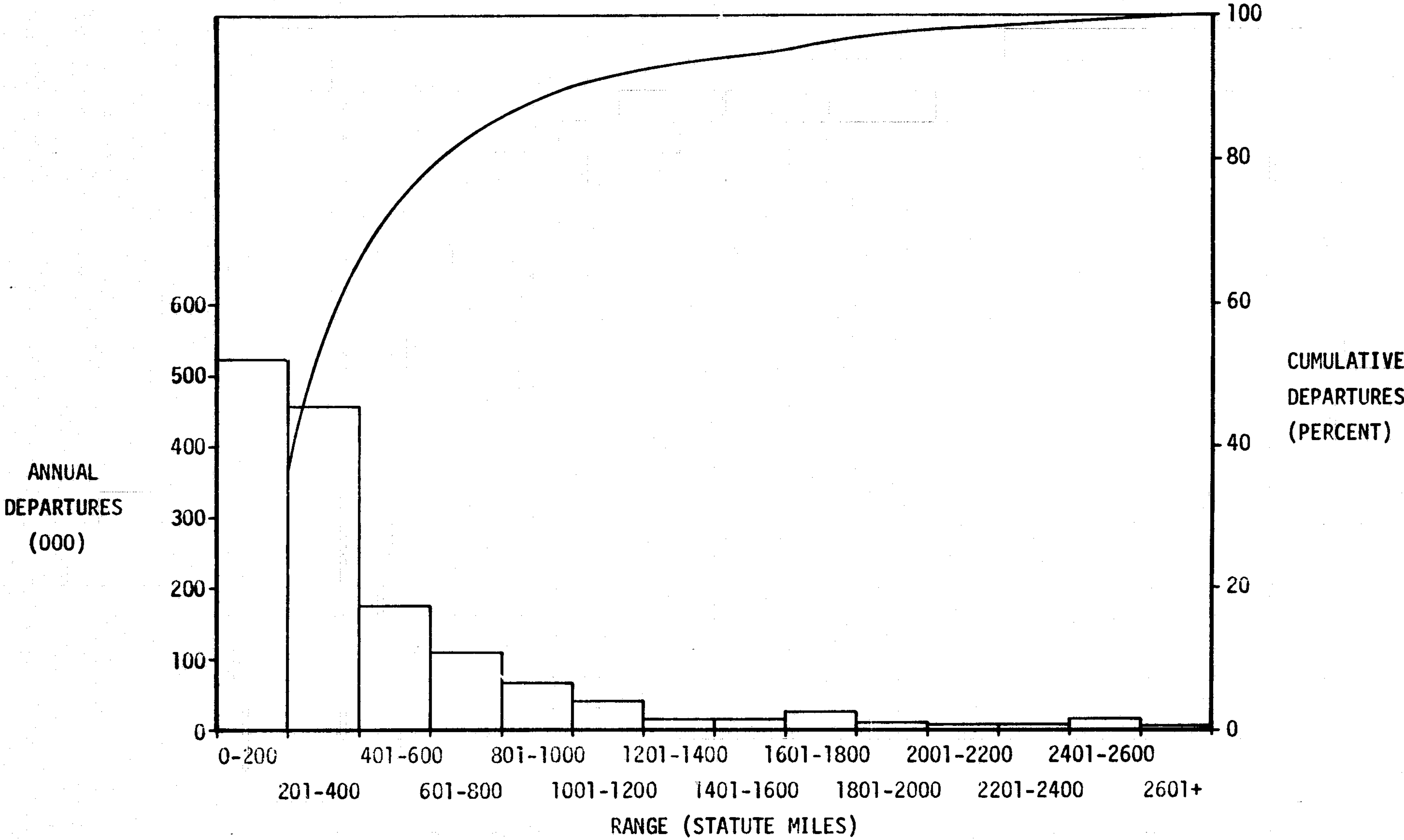


Figure 2. 1973 ANNUAL DEPARTURE DISTRIBUTION BY RANGE

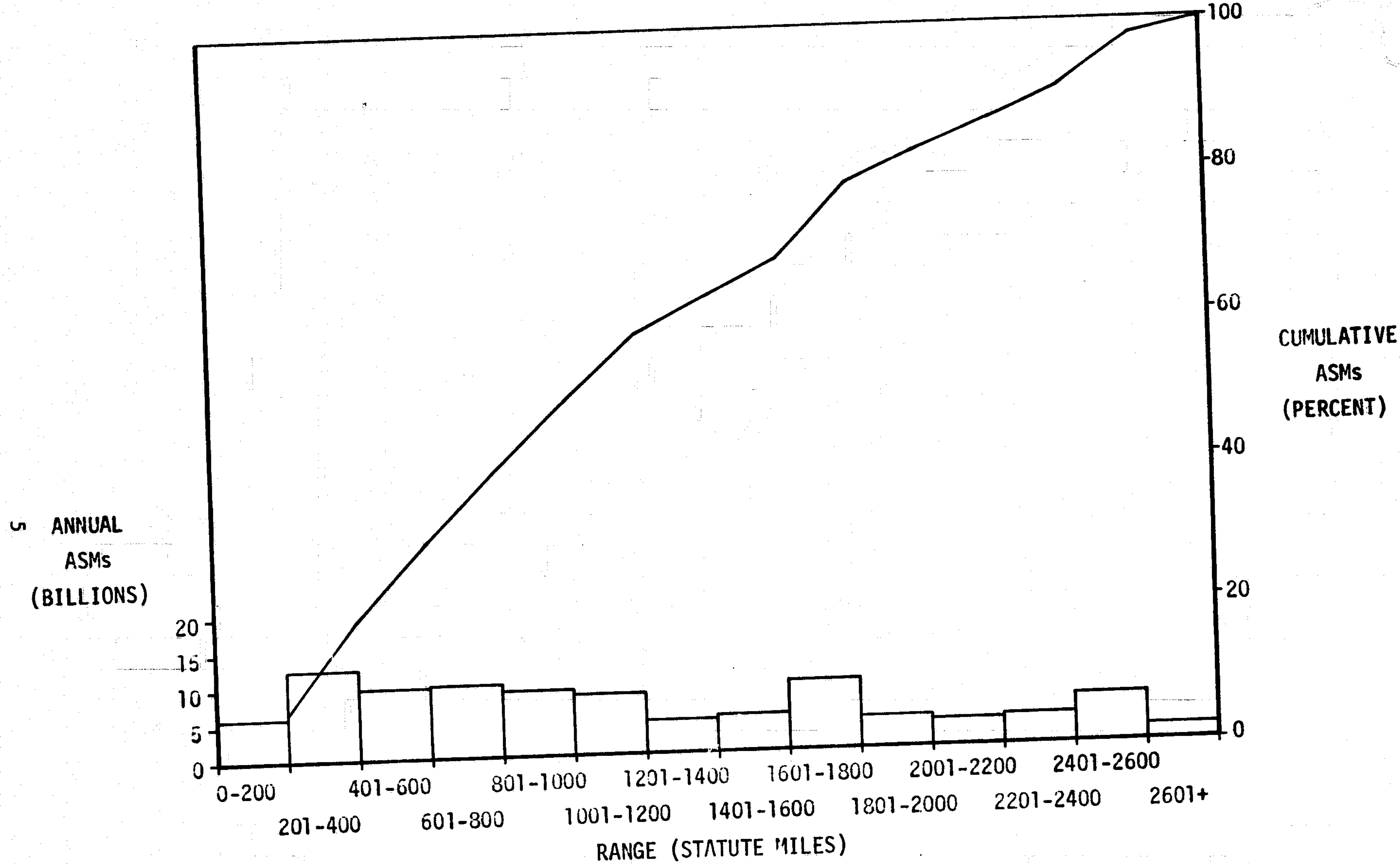


Figure 3. 1973 AVAILABLE SEAT MILE DISTRIBUTION BY RANGE

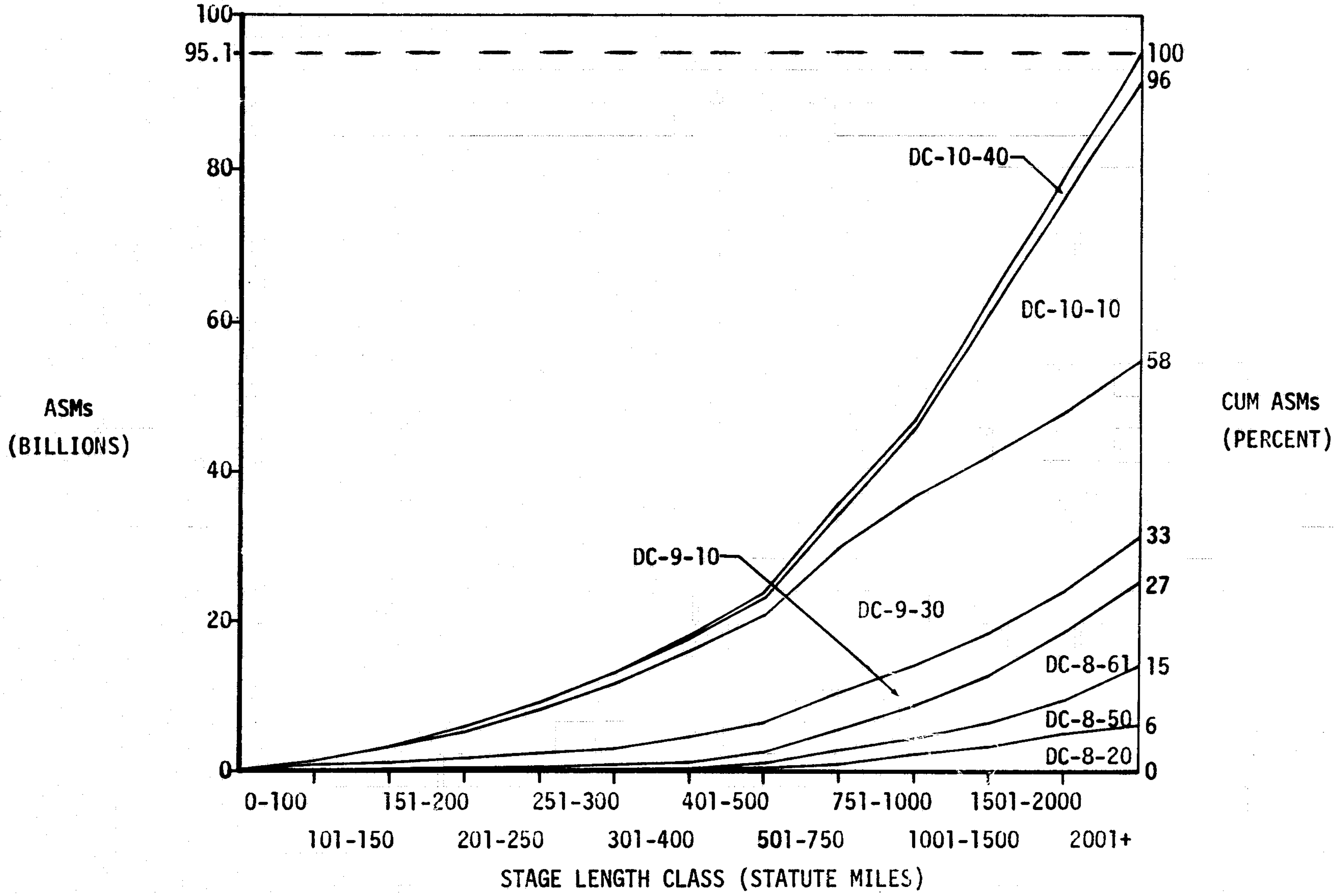


Figure 4. 1973 ASM DISTRIBUTION BY AIRCRAFT TYPE

TABLE 1

STAGE LENGTH CLASSES

Class	Stage Length (Statute Miles)	Annual Departures	
		Percent	Cumulative
1	0 - 100	13.3	13.3
2	101 - 150	10.9	24.2
3	151 - 200	11.3	35.5
4	201 - 250	10.8	46.3
5	251 - 300	9.9	56.2
6	301 - 400	10.4	66.6
7	401 - 500	7.4	74.0
8	501 - 750	10.7	84.7
9	751 - 1000	5.9	90.6
10	1001 - 1500	4.4	95.0
11	1501 - 2000	2.8	97.8
12	2001 +	2.2	100.0

1.4 Study Market Revenue Passenger-Miles

The 1973 study market's revenue passenger-mile demand was determined by applying the actual DC-Jet load factor to the ASM's. The total domestic system's load factor was 51.2 percent that year while the DC-Jet network's load factor was 49.9 percent.

Since both the DC-10 and L-1011 had not been in service long in 1973 and the number of these aircraft operating in the U.S. domestic system was small, the L-1011 markets were combined with those of the DC-10 to provide a broader market base for the DC-10 to operate from in the later years of the forecast. The DC-Jet network's load factor was not quite equivalent to the actual system load factor due to the inclusion of the L-1011 markets which were generating a slightly lower load factor than the total domestic system during the initial phases of service introduction.

1.5 Baseline Traffic Forecast (1973-1990)

From the base year 1973, passenger demand (RPM's) was projected to 1990 using the growth rates agreed upon by the RECAT Study contractors. Revenue passenger-miles were forecasted to grow at an average annual rate of

- 4.7 percent from 1973-1980
- 4.3 percent from 1981-1985
- 3.7 percent from 1986-1990

As shown in Figure 5, RPM's performed on the DC-Jet network double over the forecast period from 42.8 billion in 1973 to 87.3 billion in 1990. Extrapolating from the study market, the U.S. domestic system RPM's would be expected to grow from approximately 126 billion in 1973 to 257 billion in 1990 using the same annual growth rates.

1.5.1 Business vs. Pleasure Travel

Using the baseline revenue passenger-mile forecast, a projection has been made of the split between business and pleasure travel during the forecast period. The proportion of business travel to total passenger travel over the DC-Jet route network is expected to decrease from 46 percent in 1973 to approximately 40 percent in 1990. However, the RPM's generated by business traffic still increase from 19.7 billion in 1973 to about 34.9 billion in 1990, a 77 percent increase.

Pleasure travel over the DC-Jet route network will increase significantly with revenue passenger-miles expected to grow from 23.1 billion in 1973 to approximately 52.4 billion in 1990, as illustrated in Figure 6. This represents a 127 percent increase in pleasure travel over the study period, whereas business traffic increased only 77 percent during the same period. Increasing discretionary incomes, more leisure time, and life styles that include more travel will be major forces in continued pleasure traffic growth.

1.6 Available Seat-Mile Potential

An estimate of the available seat-miles that would be required to meet the DC-Jet RPM demand over the forecast period was made using a goal or target load factor of 58 percent. This planning load factor was established by the contractors for the baseline case. As shown in Figure 7, ASM's would grow

YEAR	AVG. ANNUAL GROWTH RATE (%)
1973-1980	4.7
1981-1985	4.3
1986-1990	3.7

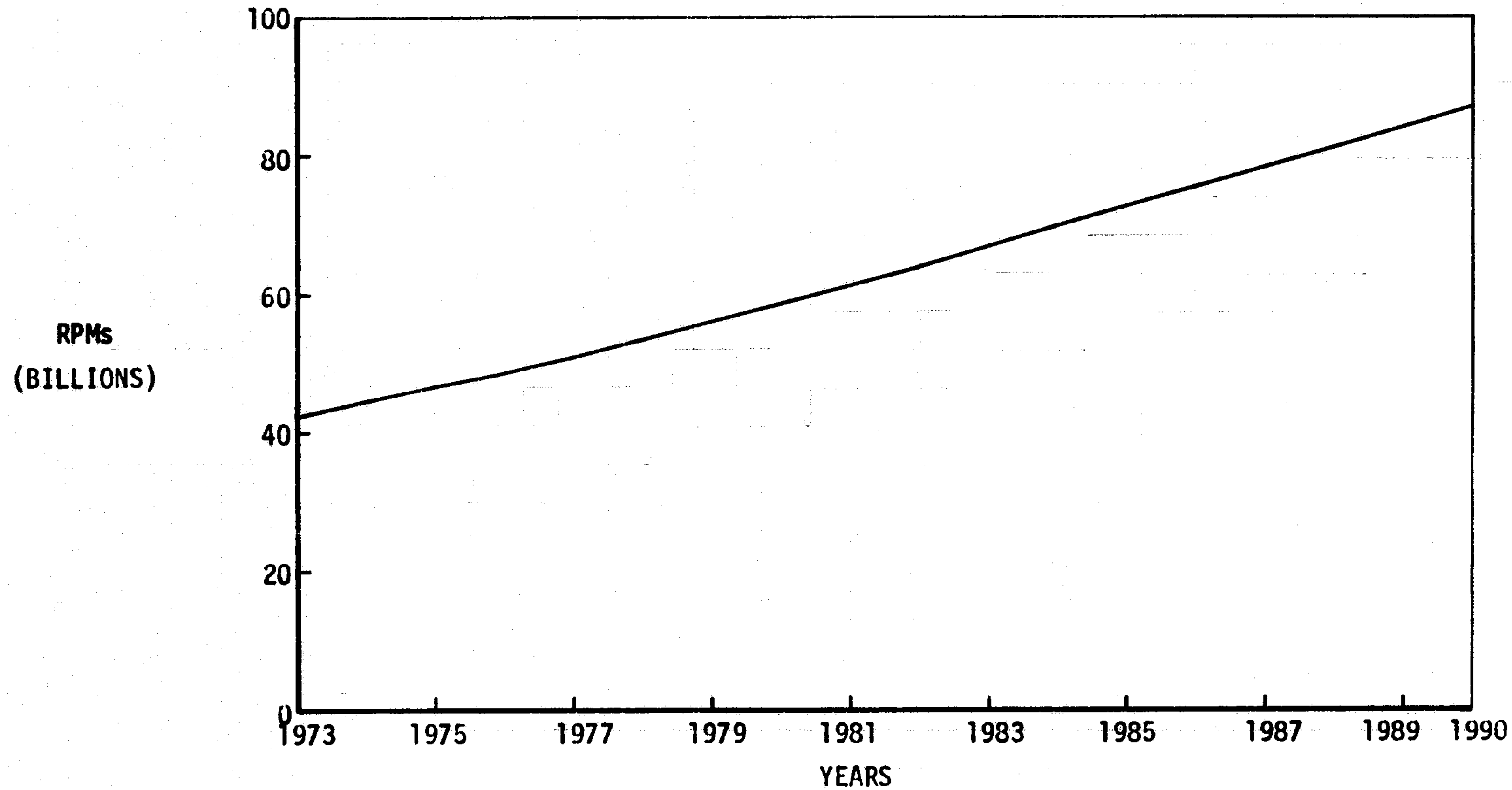


Figure 5. DC-JET REVENUE PASSENGER-MILE FORECAST (1973-1990)

YEAR	REVENUE PSGR-MILES (%)				
	1973	1975	1980	1985	1990
BUSINESS	46	46	45	42	40
PLEASURE	54	54	55	58	60

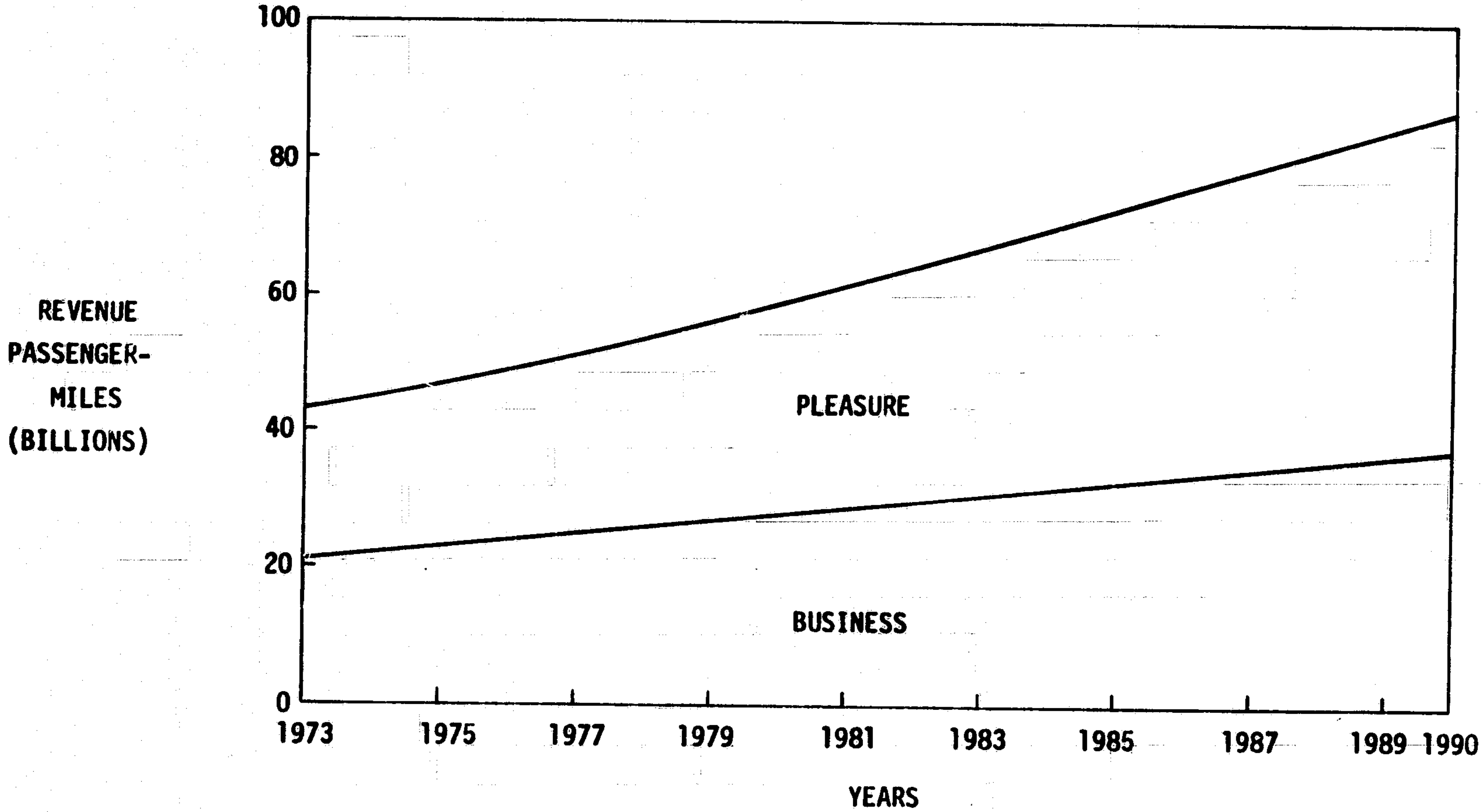


Figure 6. DC-JET BUSINESS VS. PLEASURE TRAVEL FORECAST (1973-1990)

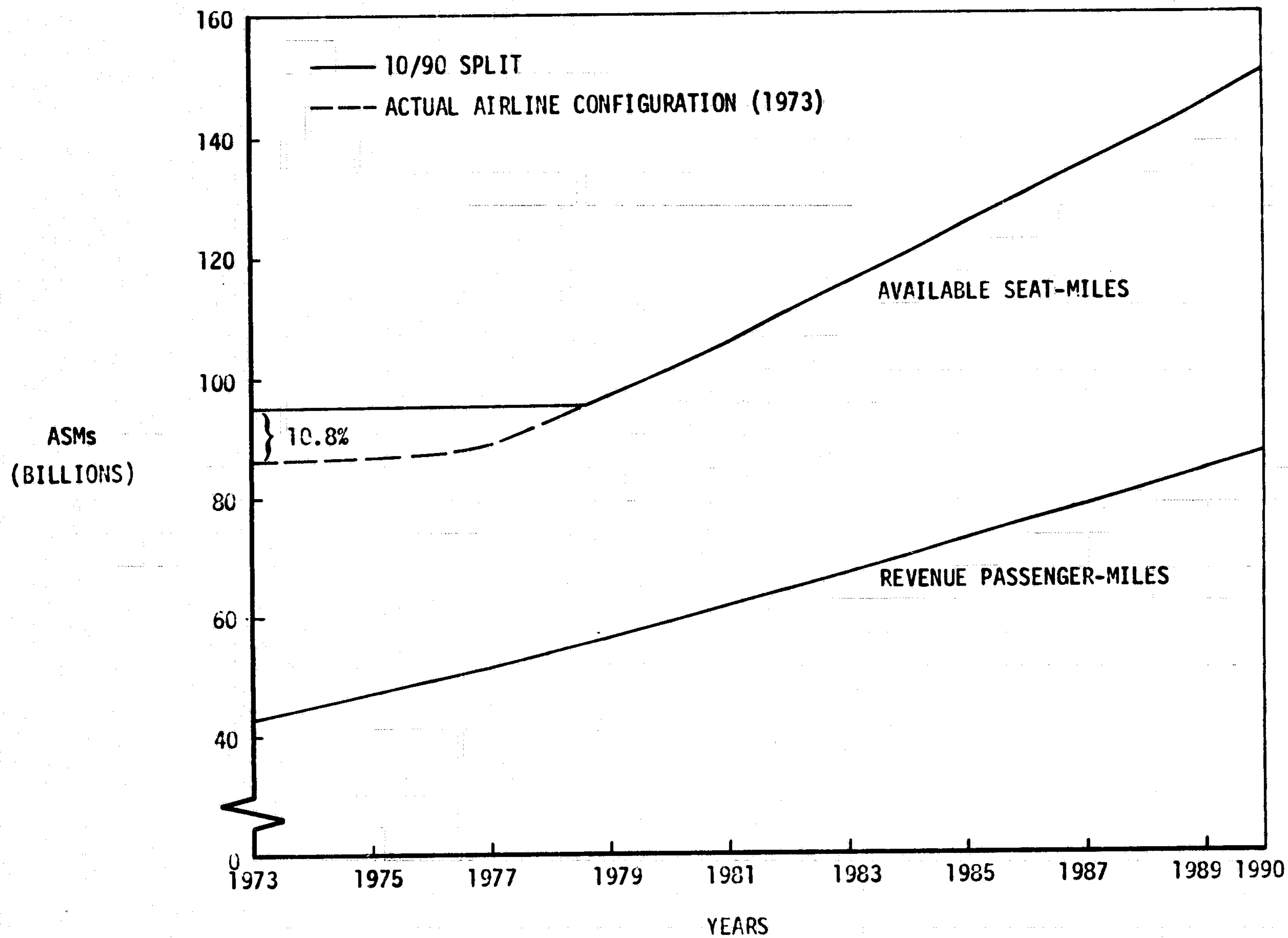


Figure 7. DC-JET AVAILABLE SEAT-MILE FORECAST (1973-1990) - GOAL LOAD FACTOR = 58 PERCENT

from 95.1 billion in 1973 to 150.5 billion by 1990, a 58 percent increase during the study period. The impact on the seat-mile forecast of the study baseline seating configurations using a 10/90 split is also depicted in Figure 7. The lower ASM forecast is based upon the actual 1973 airline seating configurations on the existing Douglas jets. The higher forecast is based upon the higher density baseline seating which overstates the actual available seat-miles by 10.8 percent in 1973. To be consistent throughout the study, the RECAT contractors kept the seating configurations constant throughout the study period. The study baseline seating was chosen since the airlines expect the 10/90 seating mix to become the industry standard by 1977. Therefore, in order to keep the baseline ASM forecast as realistic as possible, the 1973 ASM's were determined at the higher seating configurations and held constant until 1980 when the goal load factor of 58 percent was reached. In 1979 the higher density baseline seat-mile demand converged with the lower ASM forecast; then in 1980 grew at approximately the same rates as the revenue passenger-mile forecast through 1990. The effect of this contractor decision on load factor is shown in Table 2.

TABLE 2

EFFECT OF SEAT DENSITY ON LOAD FACTOR

Year	Load Factor (percent)		Δ ASMs (Percent)
	Airline Configurations	Higher Density (10/90 Split)	
1973	49.9*	45.0	10.8
1974	52.2	46.7	10.8
1975	54.6	48.4	10.8
1976	56.5	50.2	9.4
1977	58.0	52.0	7.3
1978	58.0	53.9	2.5
1979	58.0	55.9	0.0
1980-1990	-	58.0	0.0

*1973 Actual load factor experienced on DC-Jet route network

Use of the higher ASM forecast will not distort the study results significantly. It is in the years 1976-1990 that the projected demand for aircraft fuel will be important since the years 1973-1975 represent past history. Assuming the airlines adopt the higher density baseline seating in 1976/1977, it is realistic to expect load factors comparable to those estimated in the higher density ASM forecast during the 1977-1978 period. This does not mean that the airlines will not continue to strive for higher load factors, especially in times of fuel shortages. It means the carriers will be willing to accept lower load factors through increased seating capacities, thereby, allowing them to meet additional passenger growth while reducing the amount of fuel consumed per passenger-mile and the need for a large number of expensive new aircraft. In fact, this is exactly the situation the airlines have found themselves in during 1975 and 1976.

The actual available seat-miles generated varied under each operating scenario and was an output of the fleet forecasting model used in Phase II. Figure 8 illustrates how seat-mile demand was met under the various scenarios during the study period. Existing aircraft in the fleet including airplanes on hand and on order, less any retirements, were scheduled first to serve the passenger demand. If additional seat-miles were required, used aircraft from other airlines, as well as new aircraft, were obtained to fulfill the demand. Aircraft added to the airline fleets, whether new or used, were selected on their availability at a particular time, their ability to properly serve the available passenger demand as well as their fuel and operating cost characteristics.

1.7 Baseline Operating Scenario (1973-1990)

The baseline operational scenario developed reflected the actual 1973 operating environment for the domestic trunks and local service carriers. Fuel price was held constant at 15¢ per gallon and the availability of fuel was unlimited over the period. Other assumptions in this scenario included pre-energy crisis aircraft operating procedures, 1973 frequencies as a minimum, a target load factor of 58 percent, and fares in 1973 dollars which were assumed to increase over the study period at the pre-energy crisis level of inflation of approximately 6 percent per year.

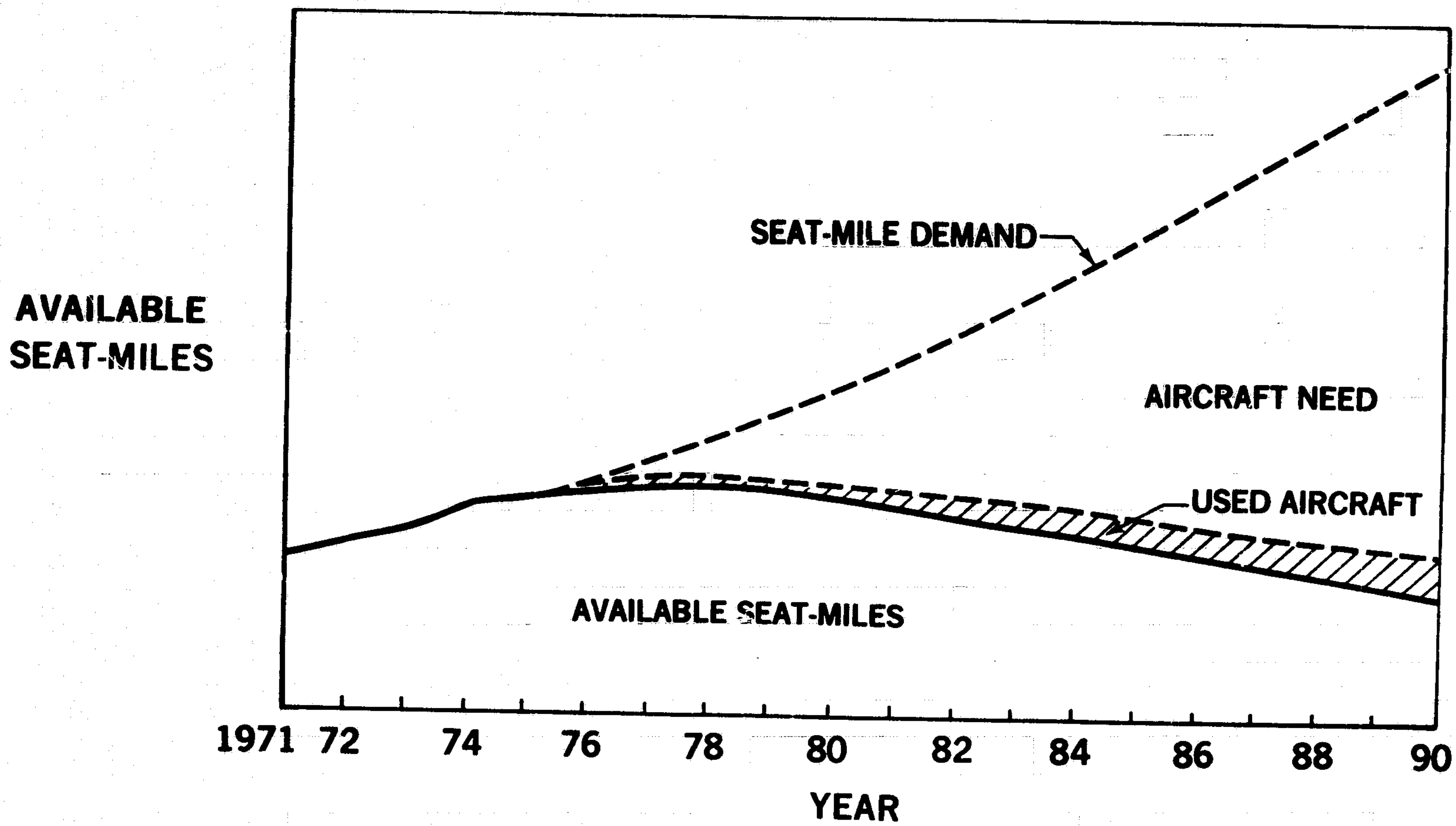


Figure 8. SATISFYING SEAT-MILE DEMAND ON DC-JET NETWORK

The fare structure used represented the 1974 CAB Phase IX levels adjusted by United Airlines to provide yield in cents per revenue passenger-mile in 1973 dollars. Figure 9 shows the yields used at various stage lengths to calculate revenue in the fleet forecast.

The baseline revenue passenger-mile demand was used for this scenario. Also all subsequent aircraft demand was to be met by the Douglas jet equipment types on hand in 1973 and new units of those types in production after 1973 (DC-9-30, DC-10-10, DC-10-40). Although this baseline scenario is academic now, due to higher fuel prices and anticipated fuel shortages, it does represent a realistic scenario for the study period assuming there was no energy crisis. This scenario will also provide the maximum upper limit on aircraft fuel demand by the U.S. domestic carriers from 1973 to 1990.

1.7.1 Alternative Operating Scenarios

Additional Baseline Scenarios -- Alternative operating scenarios were developed by varying one or several operational constraints in the baseline scenario during the 1973-1990 forecast period. Eight alternative baseline scenarios, including the initial baseline operating scenario discussed in Section 1.7, were considered where operational constraints were varied but all subsequent aircraft demand had to be met with the existing Douglas airplane types. In one scenario only fuel price was changed from 15¢ to 30¢ per gallon. This price was more representative of forecasted fuel price in constant 1973 dollars than 15¢ per gallon over the study period. A higher fuel price of 60¢ per gallon was used in another scenario to determine the sensitivity of aircraft fuel demand and fleet sizes to higher fuel prices.

Alternative Aircraft Option Scenarios - Twenty-seven additional scenarios were developed under various operational conditions including changes in fuel availability and price, hub constraints, RPM demand, and load factor. The effect of these changes on both fuel savings and fleet requirements were assessed during Phase II of the study and are documented in Section 3.0. However, in these scenarios subsequent aircraft demand was not limited to the existing 1973 Douglas airplane types. Additional aircraft requirements were also met by the 32 selected fuel conserving options including modifications and derivatives of existing airplanes as well as new 1980 technology designs.

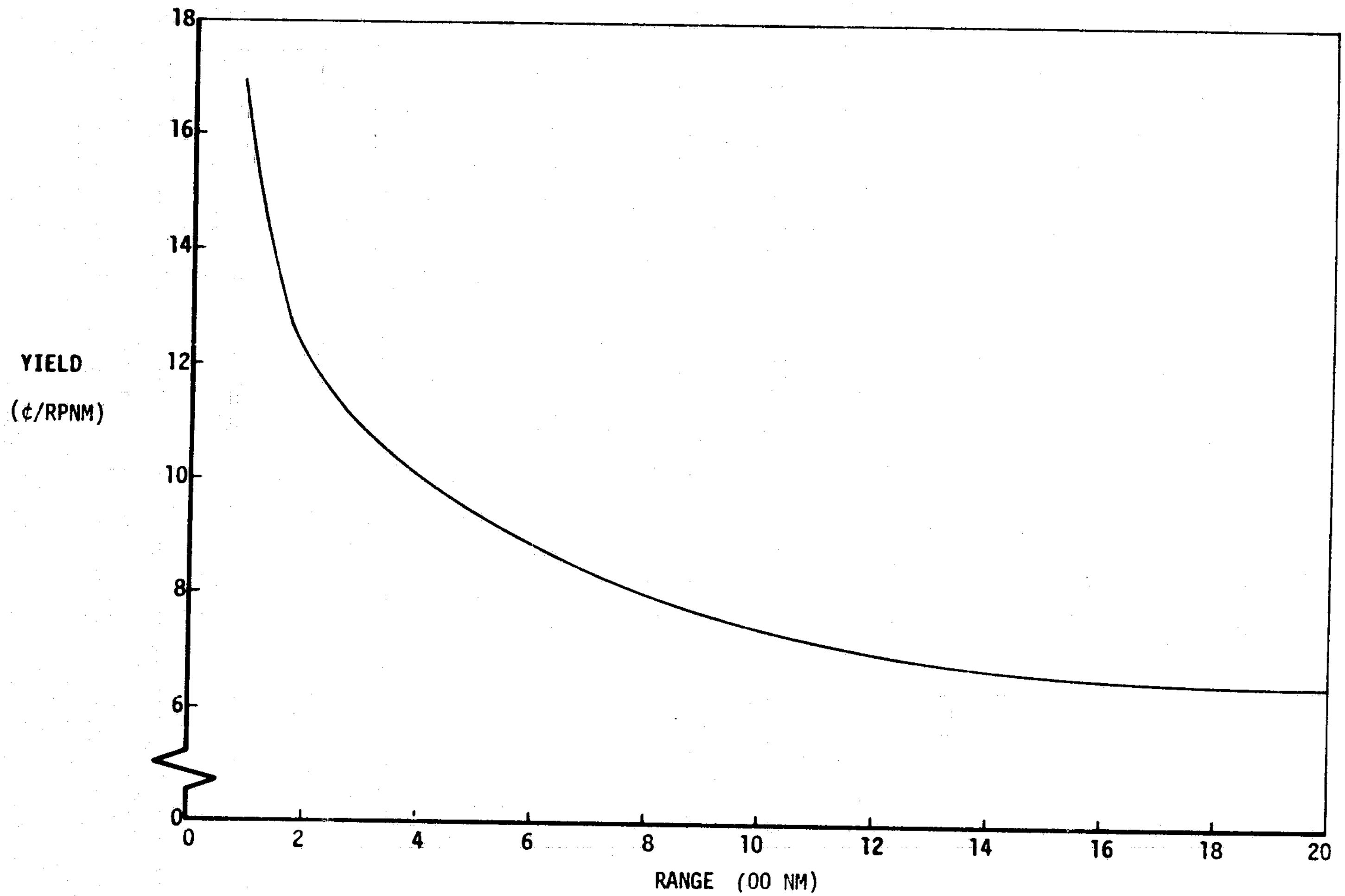


Figure 9. UAL - YIELD VS. RANGE (CAB - 1974 PHASE 9) - 1973 DOLLARS

1.8 Impact of Changes in Market Characteristics (1973-1990)

The operational constraints of fuel availability, trip lengths, changes in block speed, service levels, and fares were analyzed to determine their impact on the projected air travel demand. Significant results of this analysis are discussed and documented in Section 3.0.

1.8.1 Fuel Availability

Two fuel environments have been studied, and the results are presented in Section 3.0. The first, unlimited fuel availability and the other, fuel held constant at 1973 allocation levels throughout the forecast period. In discussions with the airlines, it was pointed out that fuel availability has not been a problem, but rising fuel costs are a major concern due to their impact on operating costs. Consequently, the nonconstrained fuel environment is considered the most realistic with airlines attempting to maximize profit at fuel prices of 30¢ and 60¢ per gallon.

1.8.2 Stage Length Distribution

Air passenger distribution by stage length has historically been skewed toward the shorter stages. This distribution has not changed appreciably with time except in extending the range to longer flights as technology permitted. Since today's technology aircraft satisfy the foreseeable nonstop range requirements, the current total travel demand distribution will be projected to hold for the study period. Fuel availability and fare levels will affect the distribution slightly. From the fleet forecasts in Section 3.0, it was determined that about 10 percent of the 1973-1990 passenger demand was not carried under a fuel allocated environment.

1.8.3 Block Speeds

The effects of changes in aircraft block speed to conserve fuel, whether from operational changes or from new design criteria, will have little impact on air travel demand. Small changes in block speed will have a minimal effect on total trip time, and passengers may not even be aware of any small differences since published airline schedules normally reflect the total trip time plus an allowance to provide for possible delays due to airport or airways congestion.

1.8.4 Service Levels

Passengers demand an appropriate frequency of service, and today's airline schedules and assigned aircraft capacities reflect this demand situation. The constraints and assumptions used in this study will determine the necessary service levels for each scenario. These include fuel availability, load factor, hub constraints, aircraft types offered - their characteristics and economics, and minimum frequency restrictions. Therefore, the frequencies required will be a resultant output from the specific scenarios studied and the aircraft types selected to best serve the market. However, to add airline realism to the study, current and future frequency limitations at the hub airports were predicted by UAL and UTRC. These hub constraints were input into the fleet forecasting model, and the impact of these constraints on passenger demand satisfied, fuel consumption and fleet sizes is presented in Section 3.0.

In order not to compromise other aspects of the model, the frequency limitations for each hub airport had to be simplified into compatible groups. This was accomplished by determining the average annual growth rates at each hub airport in the two forecast periods, 1973-1980 and 1981-1990. Then the hubs were combined into groups on the basis of "similar" 1973-1980 and 1981-1990 growth rates as shown in Table 3.

The total cumulative frequency limitations were calculated for each hub in each time period, and a weighted single "class" annual average growth rate was determined for each group of hubs. This class growth rate was used to establish the 1973-1980 and 1981-1990 annual frequency limitations for each hub in the group. Although the average growth rates determined for each class were somewhat higher or lower than the individual growth rate estimates made for some of the hubs in the group, this necessary simplification did not compromise the hub constraint objective of the study.

TABLE 3

COMPATIBLE HUB CONSTRAINT GROUPS

GROUP	HUBS	Maximum Frequency Constraints Average Annual Growth Rates (%)	
		1973 - 1980	1980 - 1990
#1	LGA	0.0	0.5
	DCA	0.8	0.0
	Class	0.36	0.27
#2	SFO	2.0	2.2
	ORD	2.1	1.6
	CLE	3.4	2.6
	EWR	4.0	3.8
	Class	2.51	2.23
#3	DTW	3.8	1.3
	JFK	4.3	1.8
	ATL	4.9	1.5
	LAX	5.3	1.4
	BOS	5.5	0.5
	PIT	5.8	0.8
	Class	4.98	1.27
#4	DEN	6.9	3.9
	MIA	8.5	1.9
	Class	7.75	2.83

1.8.5 Fares

There is little doubt that fares exert a tremendous influence on patterns and growth in air transportation. In the past, the consistent lowering of fares, whether in actual or real terms, has been a continual spur to growth. With the increase in fuel prices since late 1973, the U.S. domestic carriers have been asking for and getting higher fares. In 1975 fare increases were needed not only to cover higher fuel expenses, but also to meet higher labor costs. Concurrently, passenger traffic did not grow at the rates forecasted in early 1973. Reductions in service and higher fares stemming from a fuel allocation system would both act to retard air traffic growth, especially pleasure-oriented travel.

1.9 Fleet Forecasting Model

A Douglas computer program, the Performance Evaluation Technique, was used to analyze the alternative fleet forecasts during Phase II. With this method the operational and economic performance of the existing, modified, derivative, and new near-term aircraft options was measured in simulated airline operational scenarios and is documented in Section 3.0.

Typical inputs required for each aircraft option included the design range; seating configuration and operating procedures; block fuel, block time, and DOC plus IOC versus range; available aircraft over time; and aircraft price. Changes to these values resulting from fuel conserving operational procedures were also inputs to the program.

A single airplane or alternative competitive aircraft can be economically and operationally evaluated within the constraints of a demand model and specified operational environment. Data calculated by the Performance Evaluation Technique, by aircraft type and for the total fleet, included revenue passenger-miles, load factor, fuel burned, average range and block speed, aircraft trips and hours, total units required, new-buy units required, total investment, and profit (revenue less total operating costs). A typical computer printout from the Performance Evaluation Technique is shown in Figure 10. During the fleet forecasting phase of this study, the flexibility of this simulation technique permitted variations in the traffic demand projections, variations in the aircraft concepts offered, and selection of the optimum fleet under each alternative operating scenario in order to maximize airline profitability.

1990 ANNUAL TRAFFIC STATISTICS

SERVICE CLASS	PASSENGERS (MILL)	RPM (BIL)	MIN. TRIPS (MILL)	MAX. TRIPS (MILL)
1	10.729	5.433	0.105	0.109
2	36.264	34.174	0.259	0.356
3	46.463	29.617	0.420	0.578
4	7.789	4.208	0.067	0.120
5	51.946	13.760	0.617	2.344
TOTAL	153.210	87.192	1.468	3.507

TRANSPORTATION REQUIREMENT ANALYSIS FOR CONCEPT EVALUATION

1990

SUMMARY REPORT BASED ON MAXIMUM PROFIT

CANDIDATE TRANSPORT	TRANSPORT FLEET UNITS,PCNT		FLEET PRICE $MIL,PCNT		ANNUAL REVENUE $MIL,PCNT		ANNUAL DOC $MIL,PCNT		ANNUAL IOC $MIL,PCNT		ANNUAL PROFIT $MIL,PCNT		ANNUAL RPM BILL,PCNT	
2950	7.22	1.0	52.047	0.7	38.908	0.6	23.825	0.9	40.057	1.5	-24.973	-3.4	0.260	0.3
6941	3.29	0.5	33.885	0.5	26.678	0.4	12.995	0.5	22.119	0.8	-8.436	-1.2	0.207	0.3
9915	32.47	4.4	133.124	1.8	102.004	1.6	64.769	2.3	99.550	3.7	-62.315	-8.5	0.636	0.8
3915	417.00	57.1	2147.550	29.2	2321.455	37.5	1104.134	39.5	1256.640	47.2	-39.322	-5.4	24.076	30.4
1950	255.00	34.9	4666.496	63.4	3502.684	56.6	1495.430	53.5	1163.726	43.7	843.510	115.5	51.331	64.8
4957	15.30	2.1	329.763	4.5	196.901	3.2	95.874	3.4	78.983	3.0	22.044	3.0	2.758	3.5
TOTAL	730.32	100.0	7362.863	100.0	6188.625	100.0	2797.026	100.0	2661.074	100.0	730.518	100.0	79.268	100.0

1990 MAXIMUM PROFIT FLEET CHARACTERISTICS SUMMARY

ID	TRIPS (MIL)	TRIP-MILES (MILL)	REVENUE HOURS	BLOCK SPEED (MPH)	NO. OF UNITS	UTILIZATION (HRS/AC/YR)	FUEL MIL-TONS	REVENUE PAX-MILES	SEAT-MILES (BILL)	LOAD FACTOR	AVE RANGE	PRODUCTIVITY RPM/AC MIL
2950	0.030	3.1	17299.4	177.6	7.	2396.	0.088	0.260	0.449	0.580	103.	36.05
6941	0.013	1.9	18338.6	211.1	3.	2535.	0.041	0.207	0.357	0.580	140.	62.99
9915	0.173	15.7	85455.6	183.3	32.	2632.	0.166	0.636	1.097	0.580	91.	19.59
3915	1.482	451.2	1386598.0	325.4	417.	3325.	2.959	24.076	41.510	0.580	304.	57.74
1950	0.222	334.9	701423.6	451.7	255.	2968.	4.653	51.331	92.775	0.553	1145.	201.30
4957	0.022	18.9	42035.2	446.9	15.	2741.	0.293	2.758	4.755	0.580	872.	179.80
TOTAL	2.012	625.5	2281149.0	361.9	730.	3124.	8.200	79.268	140.942	0.562	574.	108.54

Figure 10. TYPICAL COMPUTER OUTPUT FROM THE PERFORMANCE EVALUATION TECHNIQUE

SECTION 2.0

ECONOMIC ANALYSIS

In order to assess the economic viability of each aircraft option, consistent aircraft prices and operating costs had to be developed. To provide a base for comparisons, the fuel consumption documented in the technical analysis and the operating costs of the baseline aircraft were compiled. Before an aircraft option was offered to the market, it was initially screened on the basis of fuel saved as well as direct and total operating costs.

2.1 Economic Groundrules

The groundrules used in the economic analyses were agreed upon by all the RECAT Study contractors and NASA. All costs and prices were in 1973 constant dollars. Direct operating costs were calculated using a modified 1967 ATA DOC formula and indirect operating costs were calculated using the 1970 Lockheed Committee IOC formula. Both formulas were calculated at 1973 cost levels.

2.2 Baseline Aircraft Pricing

Aircraft in the baseline that were no longer in production were priced on the basis of the latest known sale price escalated to 1973 dollars at 3.6 percent per year through 1972, then at 5 percent in 1973. This included the DC-8-20, -50, and -61 as well as the DC-9-10. For production aircraft, the DC-9-30, DC-10-10 and DC-10-40, an average new 1973 price was used. In order to calculate the aircraft modification prices, a used aircraft value in 1976 dollars was also established for each baseline aircraft. This value was derived from the 1975 known used aircraft prices and the anticipated changes in these prices for the Douglas airplanes in 1976. This 1976 used aircraft value was then deescalated to 1973 dollars.

Engine prices for the baseline aircraft were derived either from the latest known new price escalated to 1973 dollars or from the engine manufacturers' estimates of 1973 prices. Table 4 gives the total new 1973 flyaway costs, engine costs and the average 1976 used values estimated for the baseline aircraft.

TABLE 4

BASELINE AIRCRAFT PRICES - 1973 DOLLARS

TYPE	1973 AIRCRAFT PRICE - NEW (MILLIONS)	1973 PRICE PER ENGINE - NEW	AVERAGE 1976 USED AIRCRAFT PRICE
OUT OF PRODUCTION AIRCRAFT:			
DC-8-20	$ 7.21	$329,000	$ 430,000
DC-8-50	$ 8.60	$465,000	$ 2,590,000
DC-8-61	$10.30	$465,000	$ 5,600,000
DC-9-10	$ 4.10	$480,000	$ 2,420,000
IN PRODUCTION AIRCRAFT:			
DC-9-30	$ 5.15	$480,000	$ 3,890,000
DC-10-10	$18.30	$730,000	$13,820,000
DC-10-40	$21.50	$920,000	$16,500,000

2.3 Aircraft Option Prices

2.3.1 Pricing Methodology

Proposed all-new aircraft, aircraft derived from existing aircraft and modifications to existing aircraft were priced using the Commercial Aircraft Production and Development Cost (CAPDEC) computer program.

The CAPDEC model was originally developed in 1969 from the RAND military Development and Production Cost model. The RAND equations were modified to obtain calibration with known commercial aircraft prices and costs. Since 1969 CAPDEC has undergone continuous modifications and updatings and at present primarily reflects Douglas' labor and material costs as well as manufacturing experience on the DC-9 and DC-10 aircraft programs. All costs of an aircraft program were estimated by CAPDEC and are listed in Figure 11. A typical computer printout from CAPDEC is shown in Figure 12.

2.3.2 Aircraft Program Types

An aircraft program, in general, involves the advanced design (conception), development, production and marketing of an airplane. A program could be characterized in many ways. There are four distinct types of aircraft programs in the CAPDEC price prediction model.

- o All-New
- o Derivative
- o Joint
- o Modification

The primary effect of the aircraft program selection is cost allocation which can typically cause price estimates to vary by as much as 30 percent. However, each type of aircraft program has certain characteristics, therefore the program planners options are limited.

<u>All-New Aircraft</u> - The all-new aircraft program involves only one airplane type which is not derived from a previously produced aircraft. The original DC-8, DC-10, B-707 and L-1011 airplanes were priced on this type of program which also includes the normal costs associated with customer changes to the basic aircraft. In fact, most cost models only consider this type of program in estimating prices of airplanes.

Commercial Aircraft Cost and Price Prediction Model (CAPDEC) estimates all costs of an aircraft program including:

- o Development Costs
  - Initial Engineering
  - Initial Tooling
  - Development Support
  - Flight Test
  - Laboratory Testing
  - Extraordinary Development
- o Airframe Production Costs
  - Sustaining Engineering
  - Sustaining Tooling
  - Manufacturing Labor
  - Manufacturing Materials
- o Financial Position vs. Time
- o Financial Position and Costs vs. Quantity
- o Aircraft Delivery and Price Schedule

Figure 11. Commercial Aircraft Cost and Price Prediction Model (CAPDEC)

DC-10-10CL P-569N-40
RUN 1

THIS IS A DERIVATIVE AIRCRAFT PROGRAM

AIRFRAME DEVELOPMENT COSTS *

(MILLIONS OF DOLLARS)

INITIAL ENGINEERING	INITIAL TOOLING	DEVELOPMENT SUPPORT	TEST PROGRAM FLIGHT	TEST PROGRAM LAB	EXTRODINARY DEVELOPMENT	TOTAL
85.16	150.04	43.80	20.60	17.33	0.0	316.64

* EXCLUDING THRUPUTS, INVESTMENT AND WORKING CAPITAL COSTS, AND PROFITS
COST ESCALATION PRORATED PROPORTIONATELY AMONG THE COST ELEMENTS

AIRFRAME PRODUCTION COSTS * PAGE 2

(MILLIONS OF DOLLARS)

QUANTITY	PROD RATE	UNIT SUS ENG	UNIT SUS TOOL	UNIT LABOR	UNIT MATERIAL	UNIT TOTAL	CUM AV COSTS SUS ENG	CUM AV COSTS SUS TOOL	CUM AV COSTS LABOR	CUM AV COSTS MATERIAL	CUM AV COSTS TOTAL
1	1.00	0.0	0.0	11.11	3.17	14.28	0.0	0.0	11.11	3.17	14.28
3	1.00	5.00	6.96	8.45	2.78	23.19	4.11	6.39	9.63	2.96	22.78
5	1.00	3.43	4.12	7.49	2.62	17.66	3.96	5.50	8.85	2.84	21.15
10	1.00	2.17	2.15	6.42	2.42	13.16	3.25	4.11	7.81	2.66	17.84
20	3.56	1.43	1.17	5.56	2.24	10.41	2.47	2.81	6.85	2.49	14.62
30	4.78	1.14	0.83	5.13	2.14	9.25	2.07	2.19	6.34	2.39	12.98

* EXCLUDING THRUPUTS, INVESTMENT AND WORKING CAPITAL COSTS AND PROFITS

FINANCIAL POSITION VS TIME PAGE 3

	PRODUCTION RATE	PRODUCTION QUANTITY	COSTS DEVELOPMENT	COSTS INTEREST	COSTS PROD	COSTS TOT QTR	COSTS TOT CUM	REVENUE QUARTER	REVENUE CUM	CASH FLOW QUARTER	CASH FLOW CUM
1977 JAN	0.0	0.	0.	0.	0.	0.0	0.	0.0	0.	0.0	0.
APL	0.0	0.	2.	0.	0.	1.97	2.	0.0	0.	-1.97	-2.
JUL	0.0	0.	11.	0.	0.	8.97	11.	0.0	0.	-8.97	-11.
OCT	0.0	0.	29.	1.	0.	18.30	29.	0.0	0.	-18.30	-29.
1978 JAN	0.0	0.	56.	1.	0.	28.16	57.	0.0	0.	-28.16	-57.
APL	0.0	0.	92.	3.	13.	50.10	108.	0.0	0.	-50.10	-108.

AIRCRAFT COSTS AND PROFITS PAGE 4

(MILLIONS OF DOLLARS)

PRODUCTION QUANTITY	PRODUCTION RATE	CUM COSTS PROD	CUM COSTS DEVEL	CUM COSTS INTEREST	CUM COSTS TOTAL	UNIT COSTS	CUM AV COSTS	REVENUE TOTAL	PROFIT UNIT	PROFIT CUM AV	PROFIT TOTAL
1	1.0	17.	317.	40.	374.	0.0	373.83	15.	0.0	-358.99	-359.
3	1.0	78.	317.	43.	438.	31.97	145.92	45.	-17.13	-131.08	-393.
5	1.0	121.	317.	46.	485.	23.39	96.91	74.	-8.55	-82.07	-410.
10	1.0	210.	317.	53.	580.	19.04	57.97	148.	-4.20	-43.14	-431.
20	3.6	355.	317.	78.	750.	17.01	37.49	297.	-2.17	-22.65	-453.
30	4.8	484.	317.	78.	878.	12.86	29.28	445.	1.98	-14.44	-433.

AIRCRAFT DELIVERY - PRICE SCHEDULE

1980 - 94. A/C AT $14.84M
CUM - 94. A/C AT $14.84M

1981 - 96. A/C AT $14.84M
CUM - 190. A/C AT $14.84M

1982 - 96. A/C AT $14.84M
CUM - 286. A/C AT $14.84M

1983 - 76. A/C AT $14.84M
CUM - 362. A/C AT $14.84M

1984 - 48. A/C AT $14.84M
CUM - 410. A/C AT $14.84M

1985 - 48. A/C AT $14.84M
CUM - 458. A/C AT $14.84M

1986 - 48. A/C AT $14.84M
CUM - 506. A/C AT $14.84M

1987 - 48. A/C AT $14.84M
CUM - 554. A/C AT $14.84M

1976 PRICE - $14.84

Figure 12. TYPICAL COMPUTER OUTPUT FROM THE COMMERCIAL AIRCRAFT PRODUCTION AND DEVELOPMENT COST MODEL (CAPDEC)

Derivative Aircraft - The derivative aircraft program also involves only one aircraft which has been derived from a previously developed and produced parent aircraft. The market available for the derivative aircraft and its size is assumed to be independent and separate from that of the parent aircraft. However, price estimates of the derivative are based on the use and modifications of the parent's development experience and costs, including engineering, tooling, and certification as well as the benefit of the parent aircraft's manufacturing learning experiences. The derivative aircraft does not pay for these benefits received from the parent aircraft.

Joint Aircraft - A joint aircraft program involves two or more related aircraft in a single program. These airplanes are related by commonality as well as share in the development, certification, and production costs. Joint aircraft frequently differ by such parameters as range, capacity and/or number of engines, and the program is usually larger than if only one aircraft were offered. The development costs of the parts unique to one aircraft are allocated to it, whereas the development costs of the commonality items are allocated to each aircraft in the program according to its expected market share. Learning curves are established for the unique and common parts based on the production quantities of each airplane. In CAPDEC, each joint aircraft is evaluated separately using commonality and market share as parameters. The DC-10 has become a joint program, and two joint aircraft were evaluated: the DC-10-10 with lower galley and the DC-10-30 with upper galley. Normal variations in the same basic model caused by customer preferences, however, do not result in a joint aircraft program.

Modified Aircraft - The modification aircraft program involves the modification of a part of an existing aircraft. The cost of the modification is added to the base price of the current aircraft. Therefore, it is tacitly assumed that the modification has no market impact on the basic aircraft. There are two types of modification programs: (a) in-production, and (b) in-service. The in-production mod program modifies an in-production aircraft on the production line. The in-service modification program considers the alternatives of altering an airplane already in service at the manufacturer's plant or by the airline itself.

2.3.3 Pricing Assumptions

CAPDEC estimates aircraft price on the basis of total manufacturing costs plus a reasonable return for an anticipated production quantity. The RECAT Study contractors agreed to a program profit of 20 percent before income tax.

All airframe and engine pricing was performed for 1976, then deescalated to 1973 dollars at 5 percent per year. This was done to reflect the large price increases established by the airframe and engine manufacturers in late 1974 and early 1975. The effect of this was to allow a more realistic economic comparison between the selected aircraft options and the baseline aircraft already in the U.S. domestic airline fleets. The earliest introduction date of the selected options was in 1978.

Existing aircraft for which there is a market were priced on an estimate of their average new prices during 1976 as obtained from Douglas Marketing.

2.3.4 Retrofit, Modification, and Derivative Aircraft Pricing

Three CAPDEC aircraft pricing programs were used to price the twenty retrofit, modified, and derivative airplanes studied.

- Modification in-service
- Modification in-production
- Derivative

A description of each of the twenty retrofit, modified and derivative aircraft options is given in Table 5.

The retrofits were modifications added to aircraft already in-service, including aerodynamic improvements such as winglets and/or the installation of new engines. These airplanes could be modified either by the airline or at the manufacturer's plant.

Prices for the retrofitted aircraft are given in Table 6, while prices for the modification and derivative options are presented in Table 7. Each price includes the groundrule of 20 percent profit before income tax. Adequate profit on anticipated market sizes was considered to be a more appropriate pricing criterion than breakeven quantity for these airplanes. Market sizes for the retrofit options were dependent upon the number of aircraft currently available in the U.S. domestic fleets for retrofitting. Market estimates for the other options were based on inputs from the Douglas Sales Department.

TABLE 5

RETROFIT, PRODUCTION MODIFIED, AND DERIVATIVE AIRCRAFT

Aircraft	Earliest Introduction Date	DESIGN CHANGE ITEMS RELATIVE TO BASELINE AIRCRAFT						
		New Engine	General Drag Reduction	Winglet	General Weight Reduction	Composite Secondary Structure	Stretch/ Shrink	New Supercritical Wing
DC-8-20R	79	JT8D-209	X	X				
DC-8-20DR	78	-	X	X				
DC-8-20ER	79	JT8D-209	-	-				
DC-8-50R	79	JT8D-209	X	X				
DC-8-50DR	78	-	X	X				
DC-8-50ER	79	JT8D-209	-	-				
DC-8-61R	79	JT8D-209	X	X				
DC-8-61DR	78	-	X	X				
DC-8-61ER	79	JT8D-209	-	-				
DC-9-10R	78	-	X	X				
DC-9-30R	78	-	X	X				
DC-10-10R	78	-	X	X				
DC-10-40R	78	-	X	X				
DC-10-10M	78	-	X	X	X	X		
DC-10-40M	78	-	X	X	X	X		
DC-9-30D1	79	JT8D-17	-	X	X	-	+171"	-
DC-9-30D2	79	JT8D-209	X	-	X	X	+209"	-
DC-9-30D3	80	-	-	-	-	-	-	X
DC-10-10D	80	CF6-50C	X	-	X	X	-360"	X
DC-10-40D	80	CF6-50A	X	X	X	X	+360"	-

TABLE 6

BASELINE AIRCRAFT RETROFIT PRICES

1976 AVERAGE USED PRICES DEESCALATED AT 5 PERCENT PER YEAR TO 1973 DOLLARS

(20 Percent Program Profit, No Airline Prepayments)

AIRCRAFT TYPE	PROGRAM SIZE	USED AIRFRAME PRICE ($ MILLION)	AIRFRAME REFURBISHMENT ($ MILLION)	MODIFICATION PRICE ($ MILLION)	ENGINES PRICE* ($ MILLION)	ENGINES ZERO TIMED ($ MILLION)	TOTAL AIRCRAFT PRICE ($ MILLION)
DC-8-20R		.43	.27	2.01	2.64	-	5.350
DC-8-20DR		.43	.27	.15	-	.684	1.534
DC-8-20ER		.43	.27	1.90	2.64	-	5.240
DC-8-50R		2.59	.27	2.23	2.64	-	7.730
DC-8-50DR	110	2.59	.27	.15	-	.648	3.658
DC-8-50ER		2.59	.27	2.12	2.64	-	7.620
DC-8-61R		5.60	-	2.23	2.64	-	10.470
DC-8-61DR		5.60	-	.15	-	-	5.750
DC-8-61ER		5.60	-	2.12	2.64	-	10.360
DC-9-10R	324	2.42	-	.08	-	-	2.500
DC-9-30R		3.89	-	.08	-	-	3.970
DC-10-10R	280	13.82	-	.28	-	-	14.100
DC-10-40R		16.50	-	.28	-	-	16.780

* The used airframe price includes the value of the engines which could not be separated from the used price of the complete aircraft. No credit was given for the discarded engines on the aircraft retrofitted with new engines.

TABLE 7

AIRCRAFT MODIFIATION AND DERIVATIVE PRICES

1976 PRICES DEESCALATED AT 5 PERCENT PER YEAR TO 1973 DOLLARS
(20 Percent Program Profit, No Airline Prepayments)

AIRCRAFT TYPE	PROGRAM SIZE	AIRFRAME BASE PRICE ($ MILLION)	MODIFICATION PRICE ($ MILLION)	ENGINES PRICE ($ MILLION)	TOTAL AIRCRAFT PRICE ($ MILLION)
DC-9-30D1	80	5.45	.90	1.05	7.40
DC-9-30D2	80	6.91	.72	1.32	8.95
DC-9-30D3	400	4.48	--	.93	5.41
DC-10-10D	260	12.99	--	2.62	15.61
DC-10-10M	170	19.13	1.52	3.34	23.98
DC-10-40M		22.85	1.63	3.61	28.09
DC-10-40D		25.27	1.89	3.93	31.09

Some special assumptions had to be developed in pricing the retrofit options. The retrofitted aircraft price included the average used 1976 value deescalated at 5 percent to 1973 dollars, plus the mod cost, and any applicable airframe and engine refurbishment. The average used value for the baseline aircraft in 1976 was used rather than 1973 used prices, since no retrofits came on the line until 1978-1979. The used prices were estimated starting with the 1976 used values for each baseline aircraft which included the value of the engines. If a new engine was part of the modification package, no credit was given for the discarded engines. Airframe and engine refurbishment costs to bring an old aircraft up to comparable standards of a new airplane were estimated by United Airlines. These costs were added to the DC-8-20 and DC-8-50 because both aircraft will have been in service on the average of 19 and 17 years respectively by 1979. The next oldest baseline aircraft, the DC-9-10, will have been in service on the average only 12 years by 1978.

The DC-9-30D3, the baseline DC-9-30 with 92 seats, and the DC-10-10D, a shortened 200 seat DC-10, both including a supercritical wing, were priced as derivatives. A market size of 400 aircraft, independent of the DC-9 program, is assumed for the DC-9-30D3 to arrive at a price of $5.41 million. A smaller market size of 260, plus the loss of 25 DC-10-10 sales, is assumed to arrive at the price of $15.61 million for the DC-10-10D.

The remaining aircraft options in Table 7 were priced using the modification in-production program as changes to the existing baseline airplane. Once the modifications are added to these airplanes they become standard on that model on the manufacturer's assembly line. The cost of the mod plus 20 percent profit was added to the 1976 new base price as estimated by Douglas Sales for that model. A program size of 80 aircraft each for the DC-9-30D1 and DC-9-30D2, both stretches over the current baseline DC-9-30, was selected as realistically representing additional available sales in the market for modified DC-9 aircraft. The total market for all modified DC-10's during the forecast period was estimated at 170 aircraft.

2.3.5 New Near-Term (1980) Aircraft Prices

Airframe Prices - The typical pricing criterion for an all-new aircraft program is to breakeven at a production run of 250 airplanes. This criterion was agreed to by all the study contractors for the all-new 1980 technology aircraft. CAPDEC was used to generate an airframe cost curve based on dollars per pound of cost weight for the 12 N80 airplanes. The curve that was developed is shown in Figure 13.

Three families of new near-term (1980) aircraft were studied:

- N80-2.15; 200 passenger, 1,500 nautical miles
- N80-2.30; 200 passenger, 3,000 nautical miles
- N80-4.30; 400 passenger, 3,000 nautical miles

The four airplanes within a family were each optimized for a specific parameter:

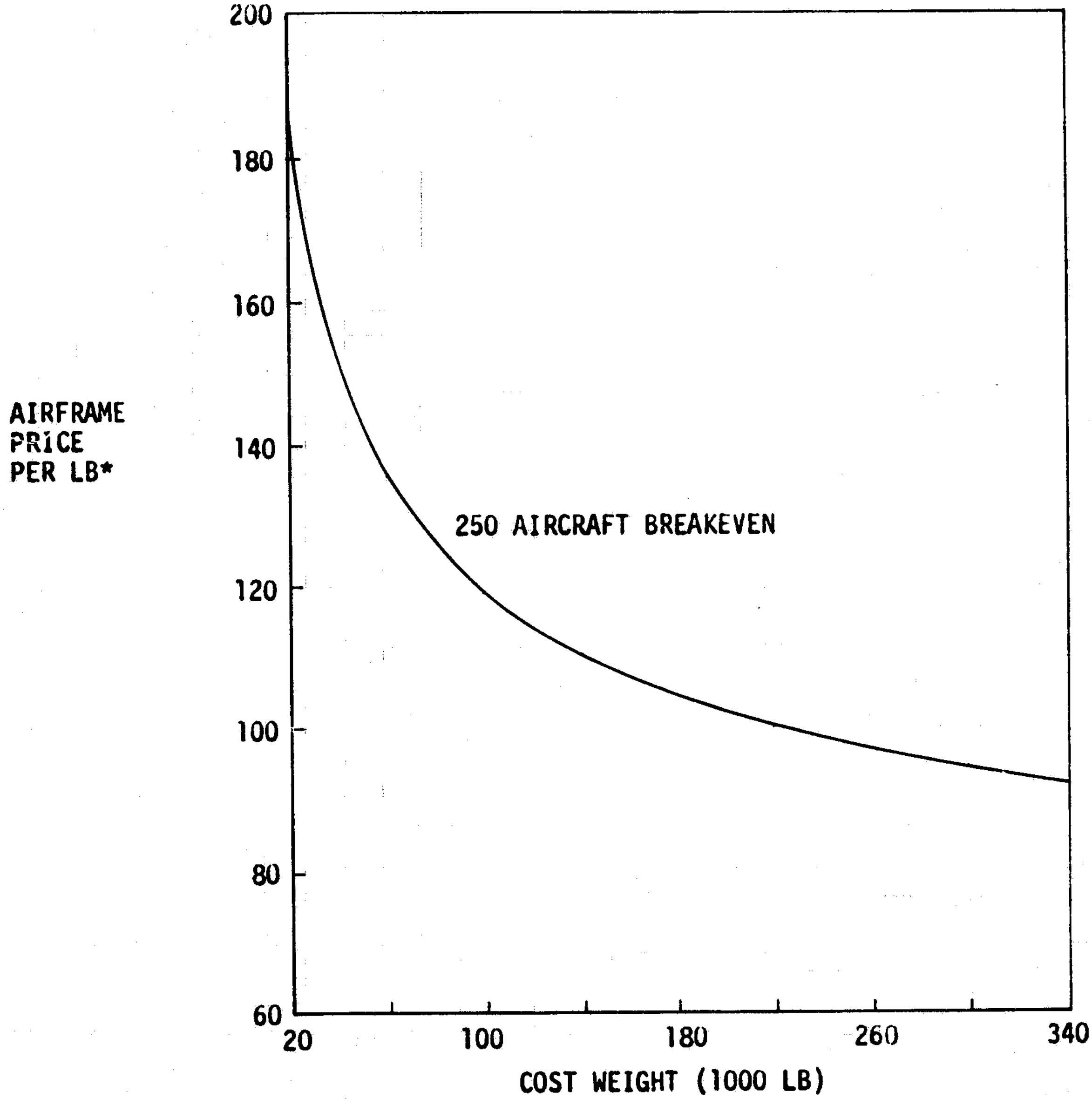
- Minimum DOC at a fuel price of 15¢ per gallon
- Minimum DOC at a fuel price of 30¢ per gallon
- Minimum DOC at a fuel price of 60¢ per gallon
- Minimum fuel burned

The dollar per pound values used in pricing the airframes of each of the N80 airplanes are given in Table 8. Due to the reduced complexity involved in manufacturing the straight wing aircraft, the new near-term designs optimized for minimum fuel consumption were all priced 3 percent lower than those aircraft optimized for minimum direct operating costs at the three fuel prices. The airplanes designed for minimum DOC's all had swept wings.

TABLE 8

Airframe Prices for the New Near-Term (1980) Aircraft
(1973 Dollars Per Pound of Cost Weight)

Optimization Parameter	DOC_{15}	DOC_{30}	DOC_{60}	MIN FUEL
N80-2.15				
Cost Weight (000)	117.3	118.5	121.6	131.3
$ Per Lb	115	115	114	109
N80-2.30				
Cost Weight (000)	123.8	126.6	128.2	137.2
$ Per Lb	114	113	113	108
N80-4.30				
Cost Weight (000)	241.6	248.0	254.4	291.6
$ Per Lb	99	98	98	92



*REDUCE DOLLARS/LB FOR STRAIGHT WING AIRCRAFT BY 3 PERCENT.

Figure 13. N80 AIRFRAME PRICES - 1973 DOLLARS

Engine Prices - Engine prices for the all-new airplanes were obtained by plotting known 1976 engine prices deescalated to 1973 dollars against their thrust capabilities (pounds of thrust at sea level, standard day). A price curve was generated between the lower thrust CFM-56 type engine applicable to the four engined N80-2.30 (200 passengers, 3,000 nautical mile range) aircraft family through to the higher thrust CF6-6D more appropriate for the twin engined N80-2.15 (200 passengers, 1,500 nautical mile range) and four engined N80-4.30 (400 passengers, 3,000 nautical mile range) families. Engine prices for the N80 aircraft are illustrated in Figure 14, while total flyaway costs for each of the twelve aircraft are given in Table 9.

2.4 Total Operating Revenue

In order to select those fuel conserving aircraft options that maximized the fleet's operational and economic performance, the operating profit for each alternative fleet forecast was determined and is documented in Section 3.0. Operating profit was defined as the total operating revenue less the total operating costs. This operating profit excludes interest and tax charges and, therefore, shows the actual economic viability of the total fleet forecast before financing costs and taxes. Total operating revenue included revenue from scheduled passenger and cargo services.

2.4.1 Passenger Revenue

The revenue generated by a particular fleet of aircraft over the forecast period 1973-1990 was based upon the 1974 CAB Phase IX Fare Levels. This fare structure was adjusted by United Airlines to provide yield in cents per revenue passenger-mile in 1973 dollars. Figure 9 in Section 1.7 shows the yields used at various stage lengths to calculate passenger revenue in the fleet forecasts.

2.4.2 Cargo Revenue

Revenue provided by cargo operations was based upon an estimate of the relationship between cargo revenue and passenger revenue. This relationship provided by United Airlines estimated cargo revenue at 3 percent of the total passenger revenue.

2.5 Direct Operating Costs

Direct operating costs include the majority of aircraft-related expenses: cockpit crew, fuel, insurance, depreciation, as well as engine and airframe maintenance including maintenance burden. The study contractors and NASA agreed to use the 1967 ATA DOC method updated to 1973 cost levels to compute comparable and consistent DOC's.

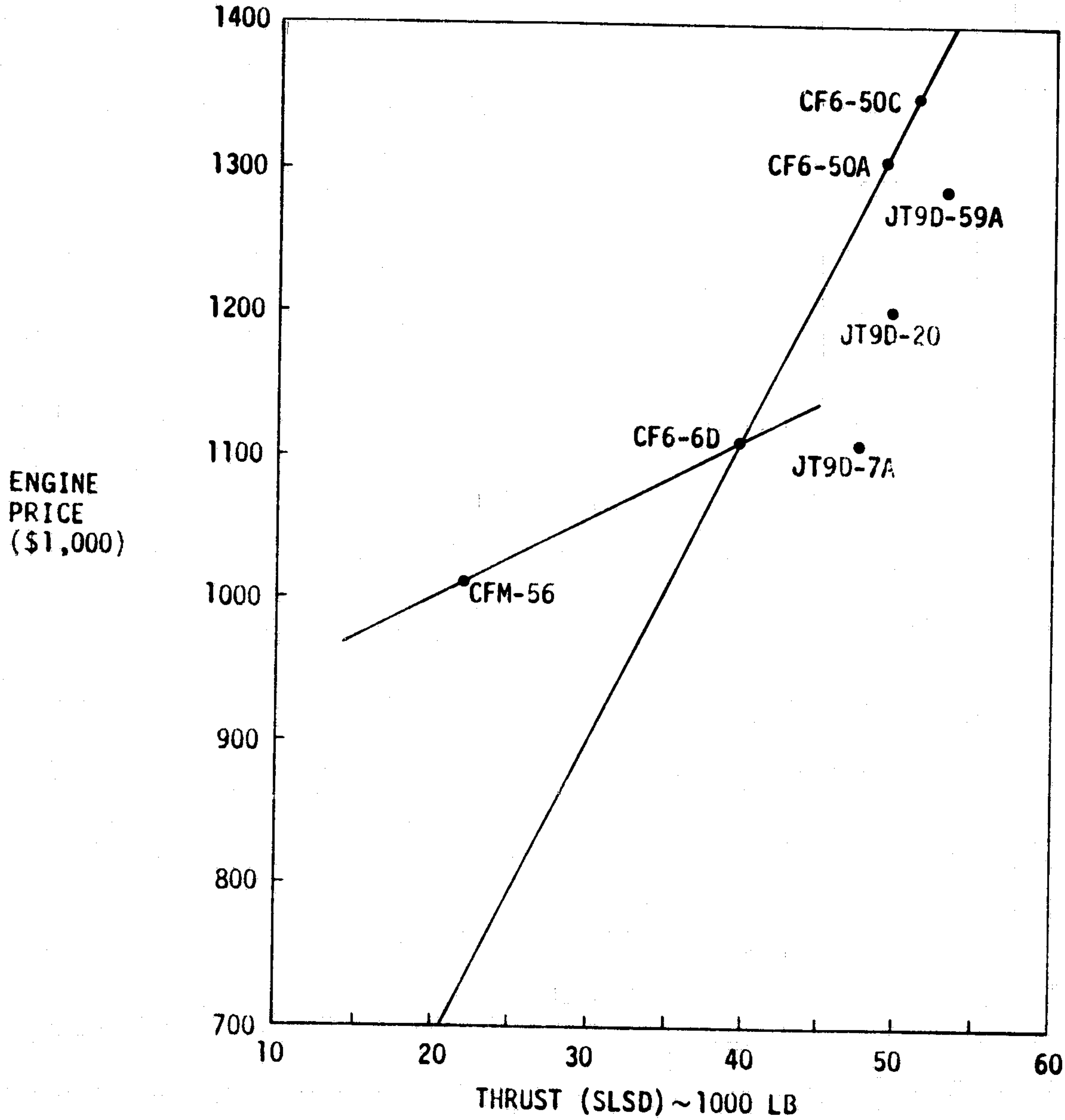


Figure 14. N80 ENGINE PRICES - 1973 DOLLARS

TABLE 9

N80 AIRCRAFT PRICES - MILLIONS OF 1973 DOLLARS

OPTIMIZATION PARAMETER \ AIRCRAFT CONFIGURATION	N80-2.15			N80-2.30			N80-4.30		
	AIRFRAME	ENGINE	FLYAWAY	AIRFRAME	ENGINE	FLYAWAY	AIRFRAME	ENGINE	FLYAWAY
DOC @ 15¢/GALLON	13.49	2.210	15.70	14.11	4.024	18.13	23.92	4.092	28.01
DOC @ 30¢/GALLON	13.63	2.080	15.71	14.31	3.976	18.29	24.30	3.780	28.08
DOC @ 60¢/GALLON	13.86	1.994	15.85	14.48	3.932	18.41	24.93	3.564	28.49
MINIMUM FUEL	14.31	1.776	16.09	14.81	3.872	18.68	26.83	3.388	30.22

To maintain consistency among the crew costs for each study airplane, the 1967 ATA crew formula updated to 1973 costs was used in calculating crew costs rather than deriving a 1973 ALPA formula. The maintenance equations were modified to reflect the work done at Douglas to improve the accuracy of estimating aircraft maintenance costs. The 1973 DOC equations used in the study are given in Figure 15. All direct operating costs were calculated at the three NASA-specified fuel prices: 15¢, 30¢ and 60¢ per gallon. Lockheed California Company, one of the RECAT study co-contractors, and Douglas worked closely together in finalizing a consistent set of DOC assumptions for the study; these are outlined in Figure 16.

2.5.1 Baseline Aircraft

The DOC's for the baseline aircraft were computed at various stage lengths for the idealized baseline flight profiles and seating densities described in Section 1.0 of the Technical Analysis (Volume I). Direct operating cost curves for the baseline aircraft at the three fuel prices are shown in Figures 17 - 23. The cost components and total DOC's were also tabulated in terms of dollars per block hour ($/HR), dollars per nautical mile ($/NM), and cents per available seat-nautical mile (¢/ASNM). This information for the baseline DC-10-10 is presented in Tables 10 - 13 along with the corresponding block speeds which were also calculated. The IOC data shown is discussed in Section 2.6. Data for the additional baseline airplanes is presented in the Appendix of this report.

2.5.2 DOC Comparison with CAB Data

The DOC's calculated by the study DOC equations were compared with the 1973 CAB DOC data* for the baseline Douglas airplanes as shown in Table 14. The CAB fuel price for the particular aircraft type was used in the study DOC equations for comparison with the CAB DOC's. CAB data for the DC-10-40 was not included in the table. This was because Northwest Airlines was the only carrier operating the DC-10-40, and it appeared that reported maintenance costs reflected initial year (1973) operations rather than typical annual in-service costs.

*Source: Civil Aeronautics Board, Aircraft Operating Cost and Performance Report, Volume IX, July 1975

CREW: $1.419\ [50.0\ (TOGW)(10^{-6}) + 35.0\ N_c + 30.0]\ t_b$

INSURANCE: $$\frac{I\ (C_T)\ t_b}{U}$$

DEPRECIATION: $$\frac{C_T\ (1-R + K_s)\ t_b}{D_a\ U}$$

MAINTENANCE-AIRFRAME

LABOR (including burden):

$$[(11.51\ (W_A)(10^{-6}) + 6.242)(t_b - t_g) + (154.9\ (W_A)(10^{-6}) - 4.78)]\ L_R$$

MATERIALS: $1.71\ (C_A)(10^{-6})\ (t_b - t_g + 2.75)$

MAINTENANCE-ENGINE

LABOR (including burden):

$$1.68\ N_E\ [(1 + .01667\ T\ (10^{-3}))\ (t_b - t_g) + 0.5]\ L_R$$

MATERIALS: $23.6\ N_E\ (C_E)\ (10^{-6})\ (t_b - t_g + 0.33)$

FUEL $C_F\ (W_{Fb})$

---

where:

TOGW	=	Max Takeoff Gross Weight (Lb)	N_c	=	Number of Crewmen
W_A	=	Airframe Weight (Lb)	t_b	=	Block Time (Hr)
N_e	=	Number of Engines	t_g	=	Ground Maneuver Time (Hr)
T	=	Static Thrust SLSD (Lb)	U	=	Annual Utilization (Hr/Yr)
C_T	=	Total Aircraft Price ($)	D_a	=	Depreciation Period (Yr)
C_A	=	Airframe Price (C_T-$N_E C_E$)($)	R	=	Residual Value (%)
C_E	=	Price per Engine ($)	K_s	=	Airframe and Engine Spares (%)
L_R	=	Maint. Labor Rate ($/Manhour)	W_{Fb}	=	Block Fuel (Gal)
I	=	Annual Insurance Rate (%)	C_F	=	Fuel Price (¢/Gal)

Figure 15. DIRECT OPERATING COST EQUATIONS - 1973 DOLLARS PER FLIGHT

- MODIFIED 1967 ATA DOC EQUATIONS
- CREW COSTS - 1967 ATA EQUATION ESCALATED AT 6% PER YEAR
- FUEL PRICES - 15¢, 30¢, and 60¢ PER GALLON
- INSURANCE RATE - 1%
- DEPRECIATION - 16 YEARS, 10% RESIDUAL
- SPARES - 15% TOTAL FLYAWAY COST
- LABOR RATE - $6.10 PER HOUR
- DAC LATEST MAINTENANCE DATA
- MAINTENANCE BURDEN - 1.8 x DIRECT AIRFRAME AND ENGINE LABOR COST
- SEATS (10/90 SPLIT) AND ANNUAL UTILIZATION BY AIRCRAFT TYPE

AIRCRAFT	SEATS	ANNUAL UTILIZATION (HOURS)	AVERAGE DAILY UTILIZATION (HOURS)
DC-8-20/20R/20DR/20ER	146	2,700	7.4
DC-8-50/50R/50DR/50ER	146	3,000	8.2
DC-8-61/61R/61DR/61ER	203	3,285	9.0
DC-9-10/10R	70	2,550	7.0
DC-9-30/30R/30D3	92	3,000	8.2
DC-9-30D1	117	3,000	8.2
DC-9-30D2	122	3,000	8.2
DC-10-10/10R/10M	277	3,285	9.0
DC-10-10D	199	3,285	9.0
DC-10-40/40R/40M	252	3,285	9.0
DC-10-40D	327	3,285	9.0
N80-2.15	201	2,900	8.0
N80-2.30	201	3,285	9.0
N80-4.30	404	3,285	9.0

Figure 16. DIRECT OPERATING COST ASSUMPTIONS - 1973 DOLLARS

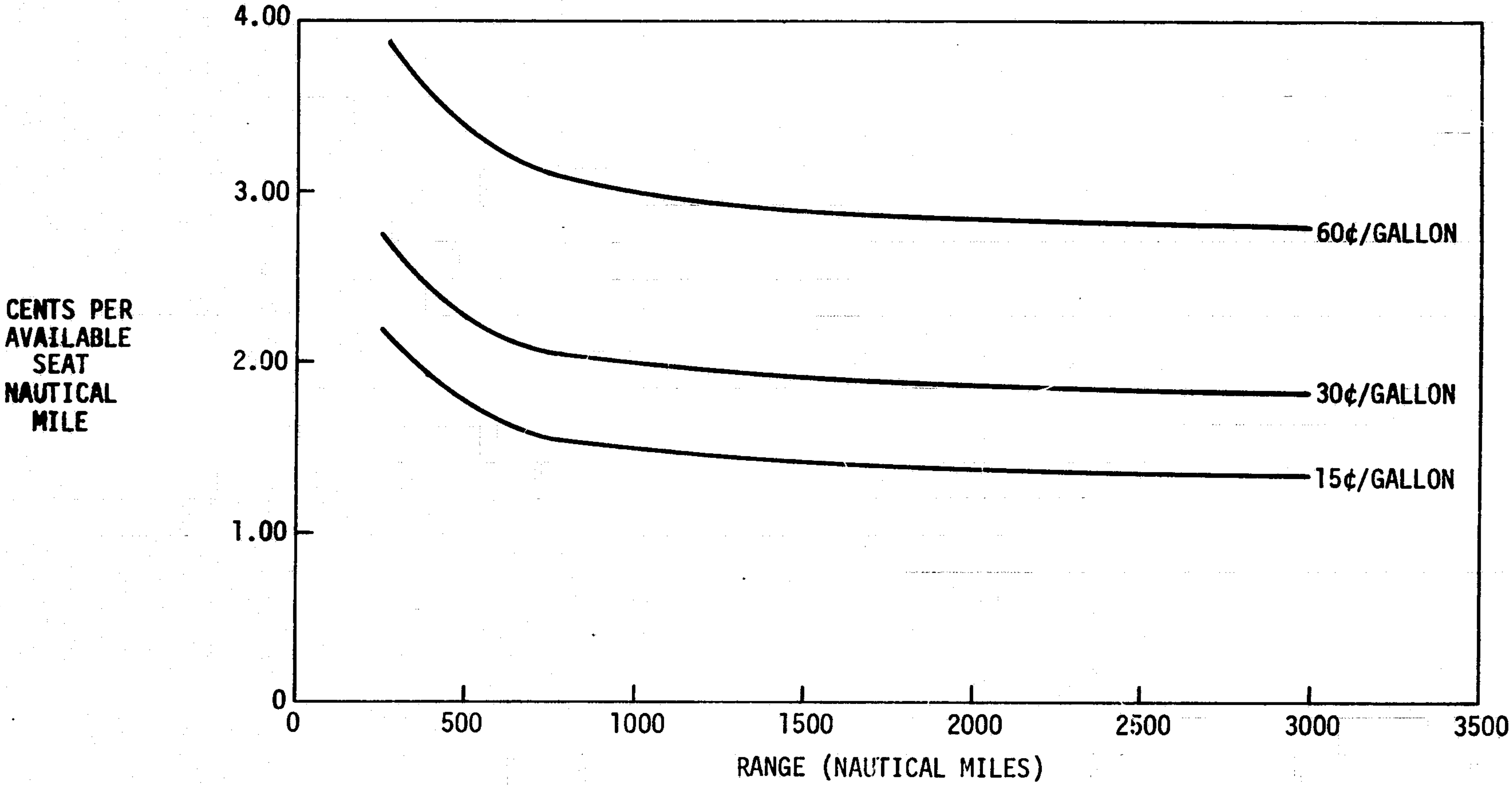


Figure 17. DC-8-21 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

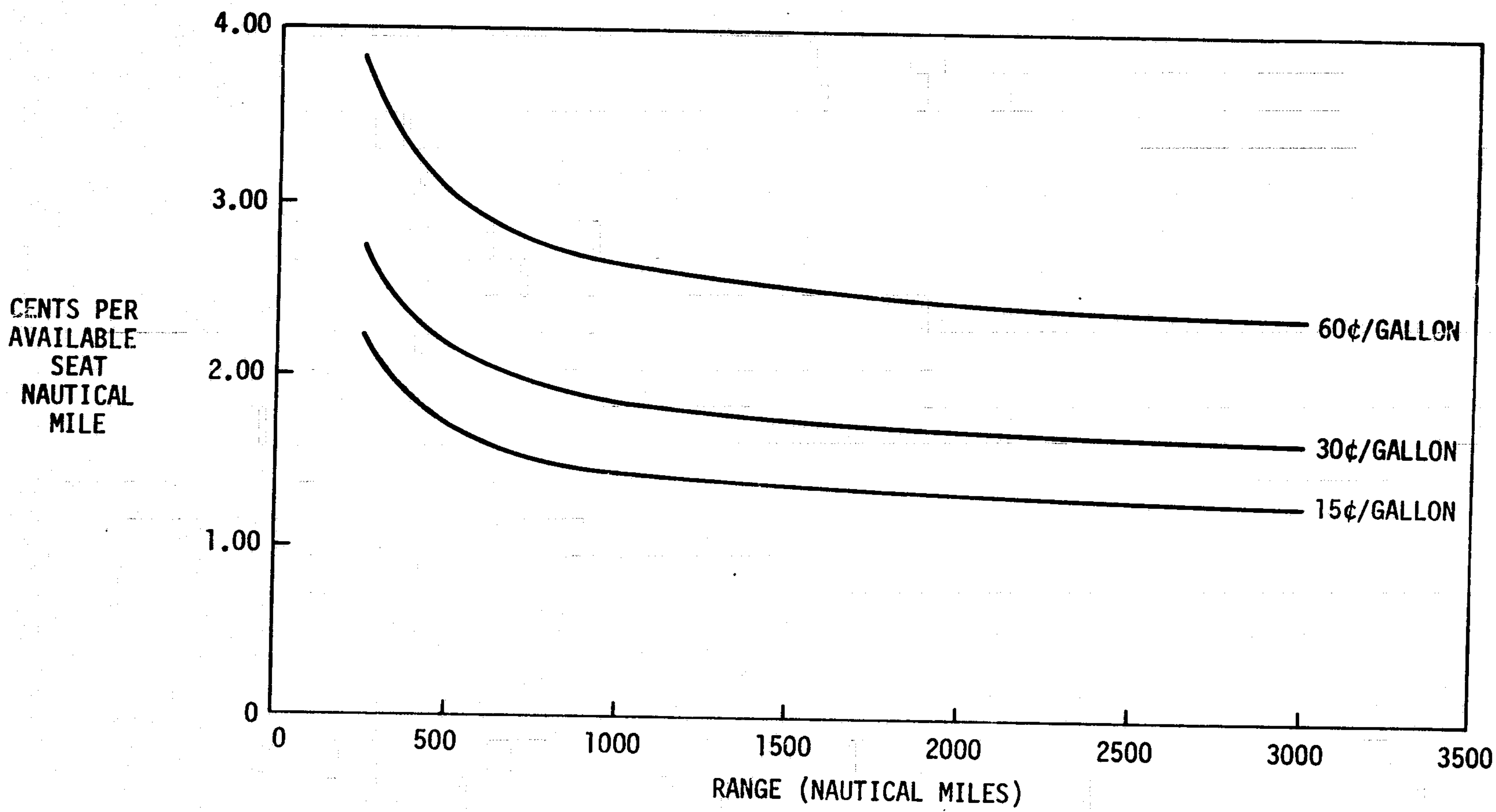


Figure 18. DC-8-52 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

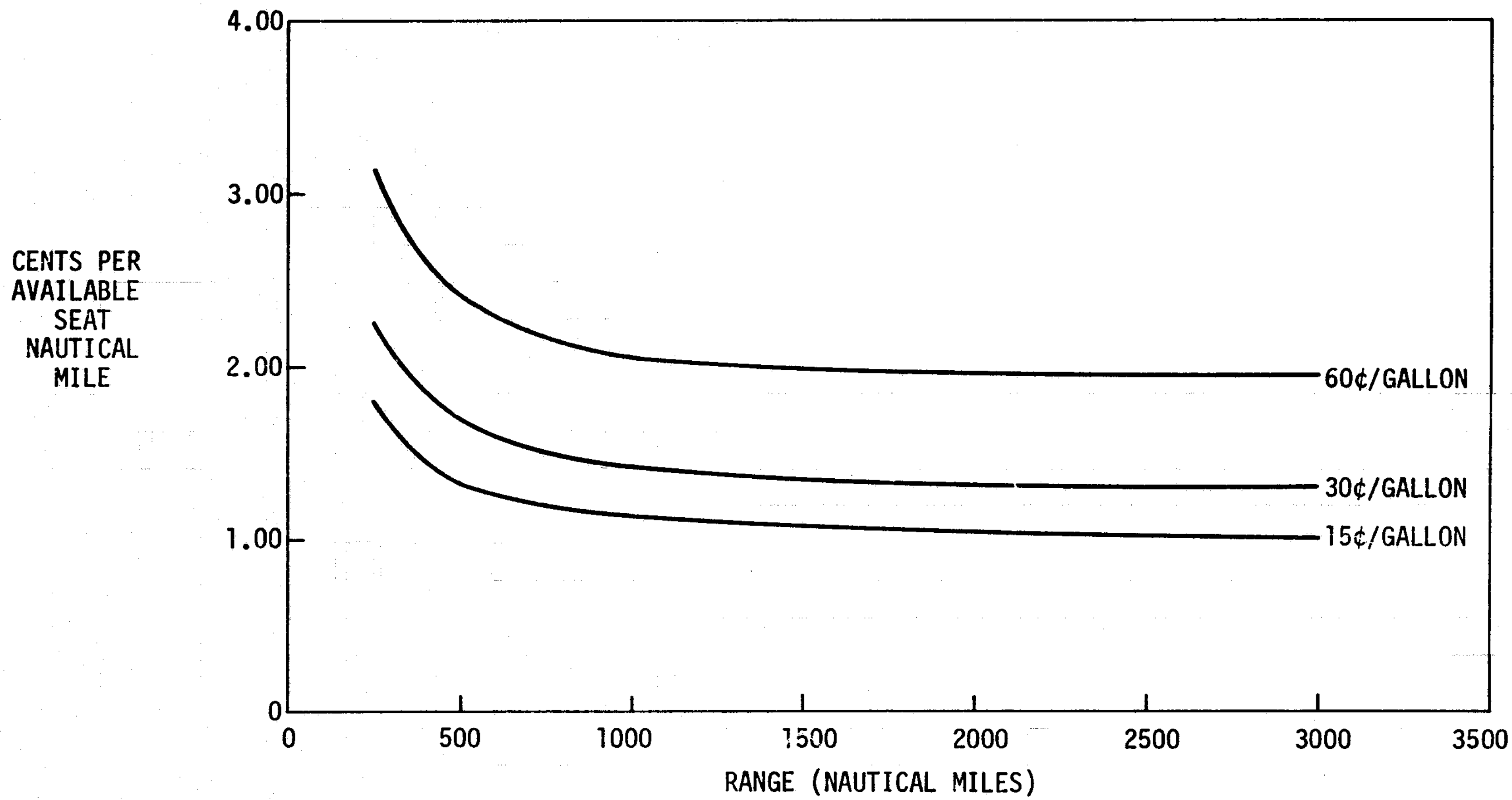


Figure 19. DC-8-61 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

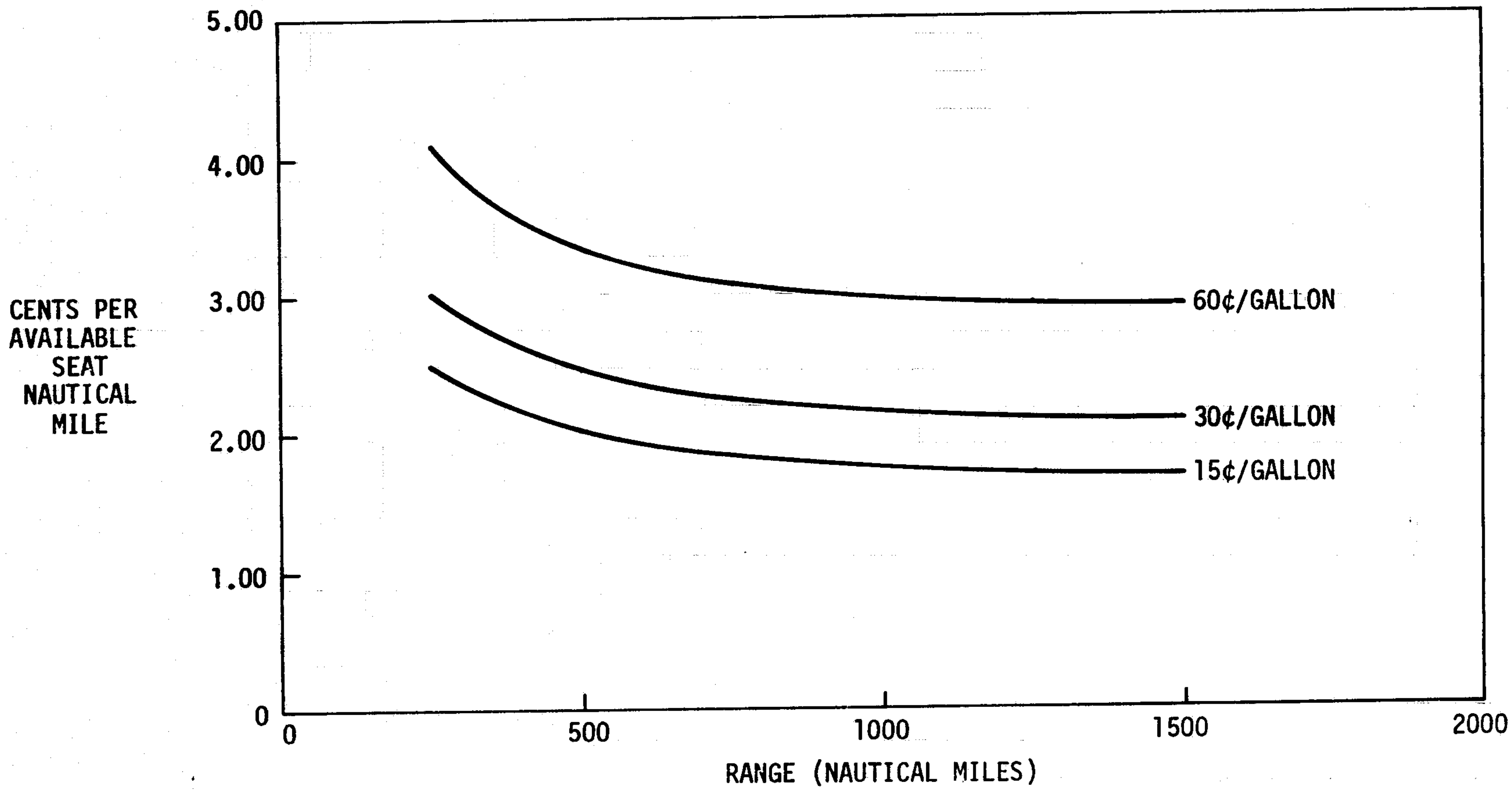


Figure 20. DC-9-15 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

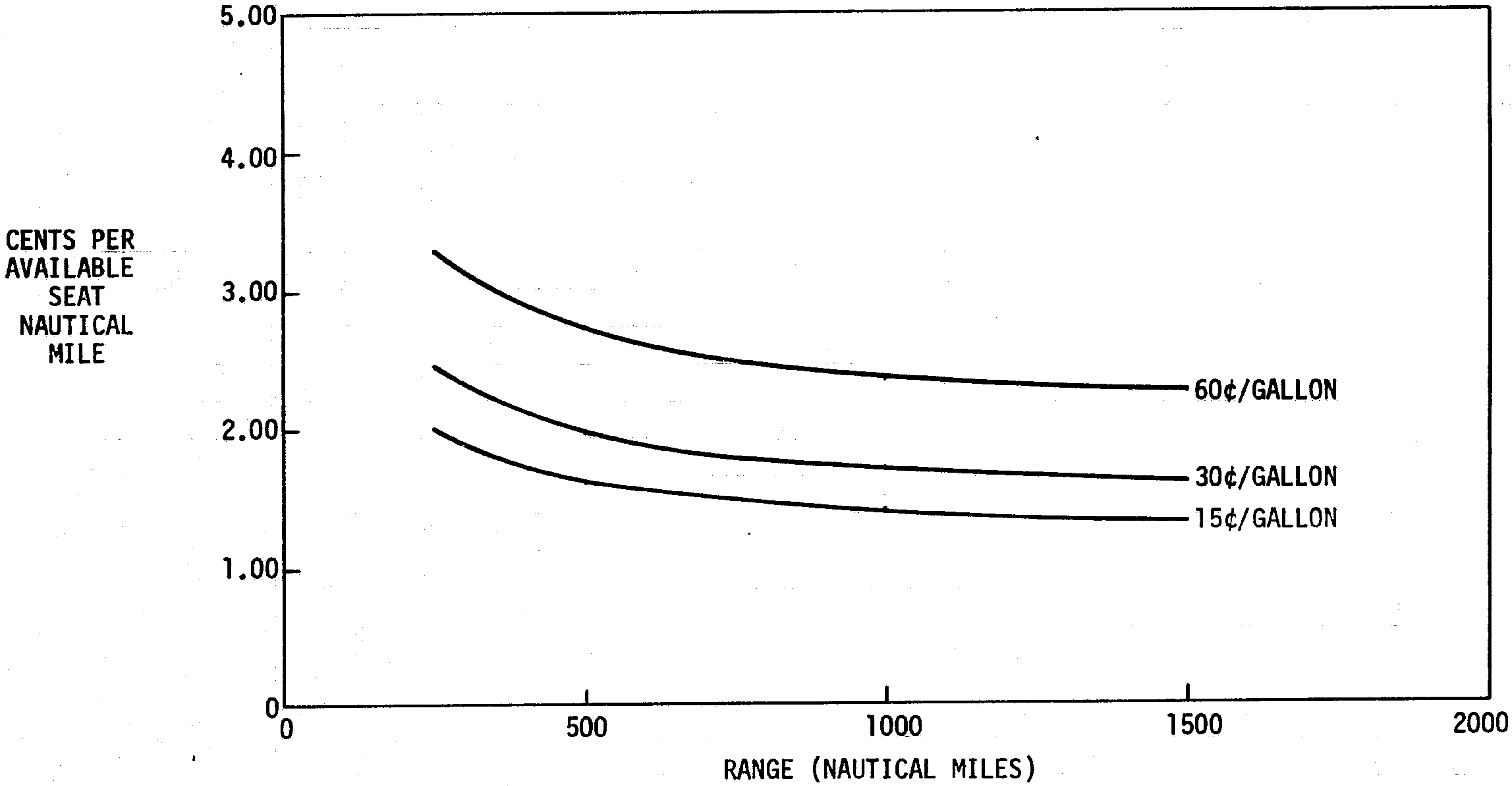


Figure 21. DC-9-32 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

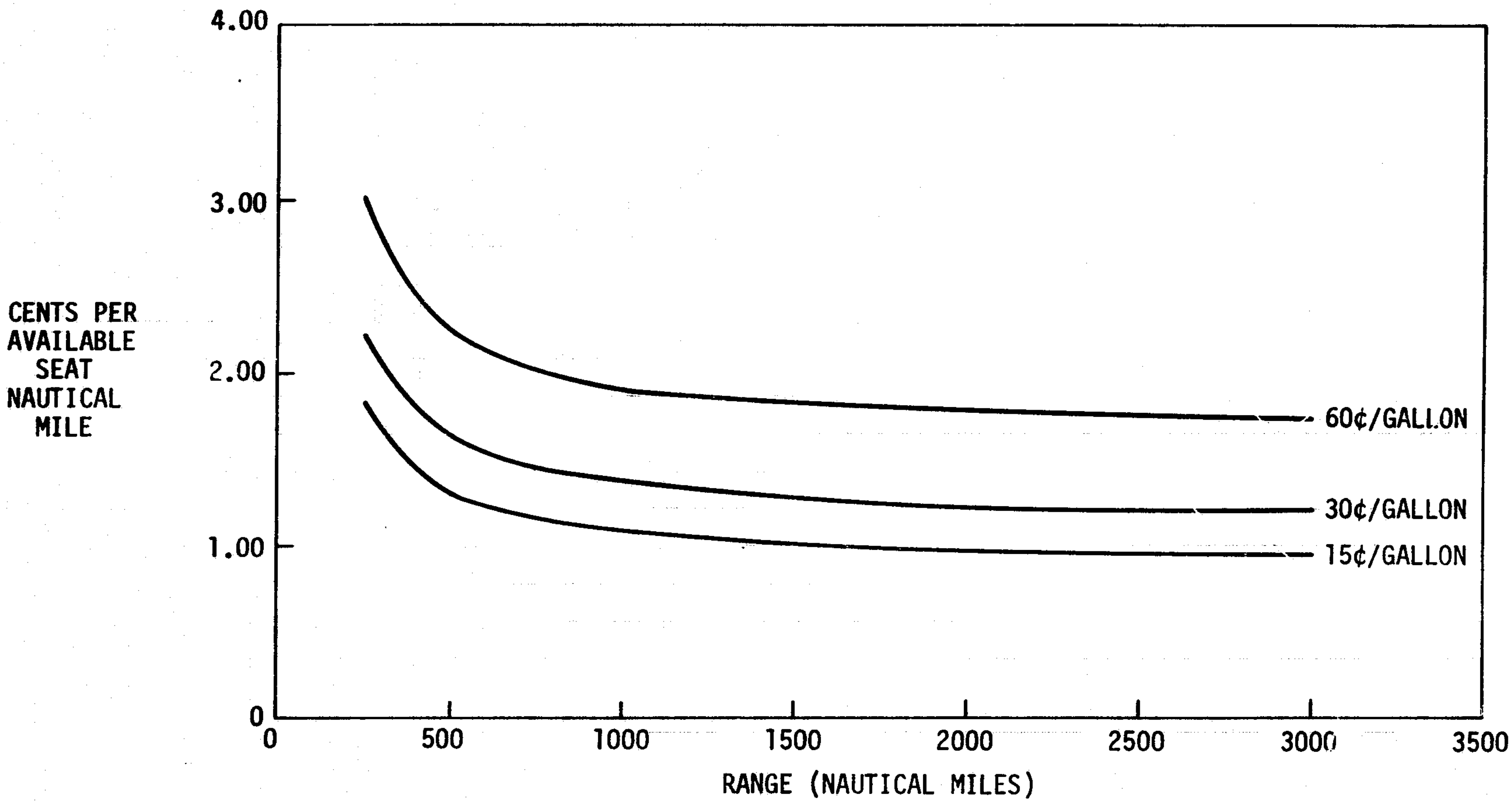


Figure 22. DC-10-10 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

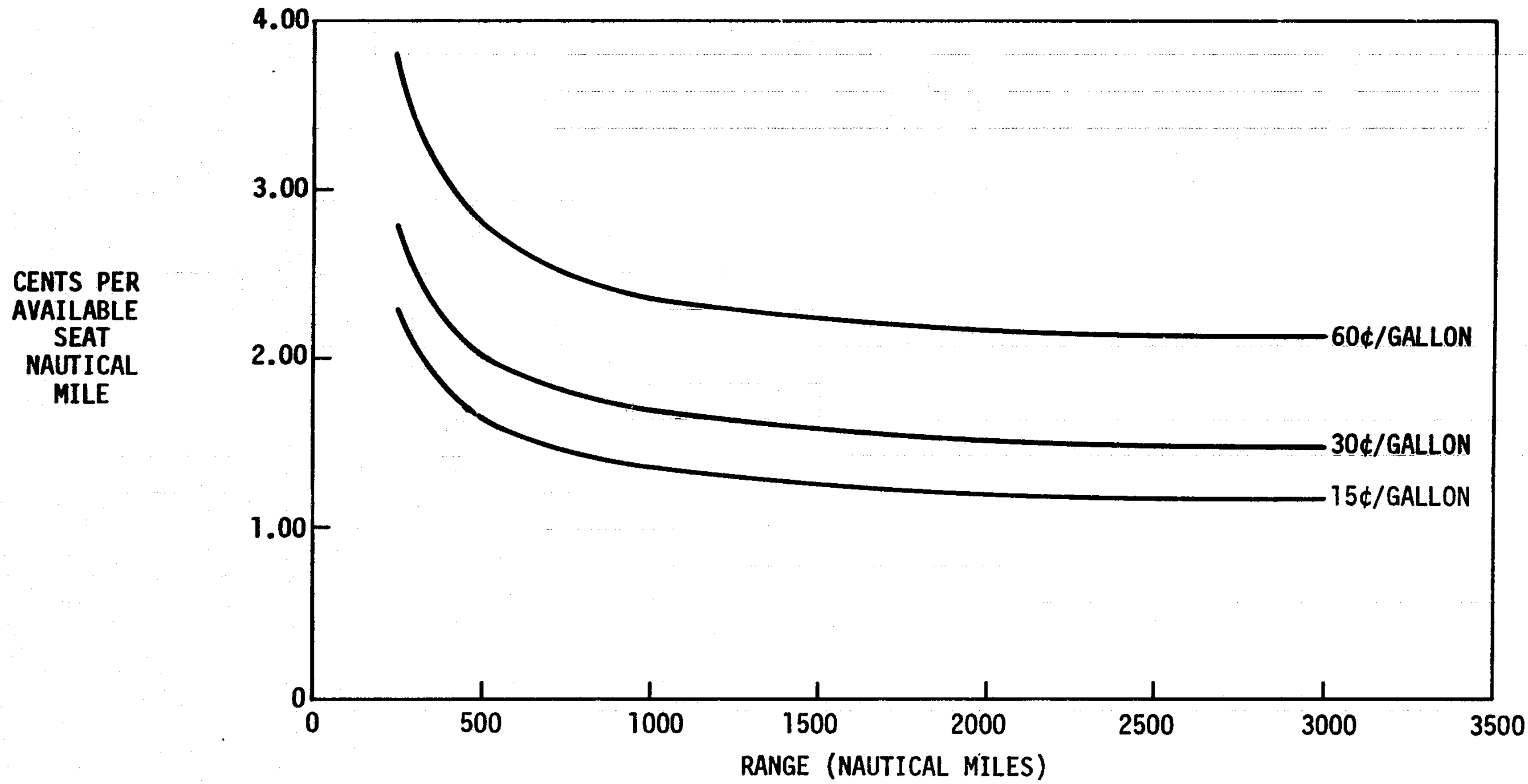


Figure 23. DC-10-40 BASELINE - DIRECT OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

TABLE 10

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

AVERAGE STAGE LENGTH = 870 NAUTICAL MILES

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	1512.33	9.23	3.33	3955.25	24.13	8.71
250	275	1386.55	5.05	1.82	2903.02	10.57	3.82
500	355	1295.85	3.65	1.32	2144.31	6.05	2.18
750	389	1256.28	3.23	1.17	1769.20	4.55	1.64
1,000	408	1231.68	3.02	1.09	1553.22	3.81	1.37
2,000	445	1200.83	2.70	.97	1192.33	2.68	.97
3,000	459	1197.69	2.61	.94	1057.38	2.30	.83
AVG. STAGE	399	1241.61	3.11	1.12	1652.37	4.14	1.49

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$18,300,000

FUEL COST = 15¢/GALLON

TABLE 11

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1817.39	11.09	4.00			
250		1691.49	6.16	2.22			
500		1600.71	4.51	1.63			
750		1566.00	4.03	1.46			
1,000		1542.37	3.78	1.36			
2,000		1523.79	3.42	1.24			
3,000		1533.68	3.34	1.21			
AVG. STAGE		1550.47	3.89	1.40			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $18,300,000

FUEL COST = 30¢/GALLON

TABLE 12

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2427.52	14.81	5.35			
250		2301.38	8.38	3.02			
500		2210.43	6.23	2.25			
750		2185.44	5.62	2.03			
1,000		2163.76	5.30	1.91			
2,000		2169.70	4.87	1.76			
3,000		2205.66	4.80	1.73			
AVG. STAGE		2168.20	5.43	1.96			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $18,300,000

FUEL COST = 60¢/GALLON

TABLE 13

DC-10-10 BASELINE - DOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT-N.MI)

AVERAGE STAGE LENGTH = 870 NAUTICAL MILES

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.489	.292	.226	.206	.196	.180	.175	.201
INSURANCE	.122	.073	.057	.052	.049	.045	.044	.050
DEPRECIATION	.805	.480	.372	.339	.323	.296	.287	.331
MAINTENANCE:								
AIRFRAME	.972	.423	.241	.180	.150	.104	.089	.164
ENGINE	.270	.153	.113	.102	.096	.086	.082	.098
FUEL @ 15¢/GAL	.672	.401	.310	.288	.275	.262	.264	.279
TOTAL DOC	3.330	1.822	1.319	1.167	1.089	.973	.941	1.123
FUEL @ 30¢/GAL	1.344	.802	.621	.576	.550	.524	.528	.559
TOTAL DOC	4.002	2.223	1.630	1.455	1.364	1.235	1.205	1.403
FUEL @ 60¢/GAL	2.687	1.603	1.241	1.151	1.100	1.047	1.056	1.117
TOTAL DOC	5.345	3.024	2.250	2.030	1.914	1.758	1.733	1.961

TABLE 14

COMPARATIVE DIRECT OPERATING COSTS, 1973

	DC-8-20	DC-8-50	DC-8-61	DC-9-10*	DC-9-30*	DC-10-10
Study DOC's ($/BLK HR)	$ 854	$ 839	$ 892	$ 477	$ 505	$1190
CAB DOC's ($/BLK HR)	$ 908	$ 839	$ 958	$ 546	$ 518	$1326
$\frac{CAB}{DAC}$	1.06	1.00	1.07	1.14	1.03	1.11
CAB FUEL PRICE (¢/GAL)	12.76	12.25	12.52	12.16	12.04	12.48

*U.S. Domestic Trunk Airlines

The CAB direct operating cost for a particular baseline airplane was generally 5 to 10 percent higher than the calculated cost using the 1973 updated ATA method. This was due largely to the following differences between the methods:

- The ATA DOC method is based upon statistical averages and estimates representative but not actual airline costs, while the CAB DOC for a particular aircraft type is a weighted average of all the airline-reported data.

- Idealized flight profile data was used to determine study block times and fuel burns while the CAB data represents the averages for airlines operating similar equipment under different operating conditions and policies.

- Idealized flight profile data used for block speeds and fuel burns did not take into account wind conditions, nonoptimum altitude and temperature variations, ground time differences or air traffic delays, nor fuel spillage, tankering, or the ferrying of aircraft.

- Insurance and Depreciation are basically fixed costs and do not vary with aircraft performance nor by stage length.

Table 15 illustrates that the airline-reported data for a particular aircraft type also varies substantially by airline from the CAB average for that airplane type. Delta Airlines' DC-10-10 generated the highest DOC at 31 percent higher than the CAB DC-10-10 average, while Continental Airlines' DC-10-10 DOC's, the lowest, were 19 percent lower than the average. Not only are the total DOC's per block hour for the same airplane type different for each airline, but there are also significant differences between the elements comprising the direct operating costs for the same airplane in different airline fleets as shown in the range column on the table.

Due to these large variances in airline DOC's, use of the 1973 updated ATA DOC method for the study equations was appropriate for a simulated system study. This method did allow a reasonable and consistent economic comparison of the many aircraft options.

2.5.3 Effect of Fuel Price on DOC

The dramatic effect fuel price has on direct operating costs is illustrated for the baseline aircraft in Figures 24 - 26. Fuel costs represent about 25 percent of DOC with fuel at 15¢ per gallon, 40 percent at 30¢ per gallon, and 50 to 60 percent, more than one-half of all direct operating costs, at 60¢ per gallon. With all other DOC elements held constant, an increase in fuel price from 15¢ to 30¢ per gallon raises DOC's by about 25 percent. An increase from 30¢ to 60¢ per gallon raises DOC's by approximately an additional 40 percent.

2.5.4 Impact of Fuel Conserving Operational Procedures on DOC

The effect of fuel conserving operational procedures on direct operating costs for each of the baseline airplanes was also investigated. Two levels of improved flight operations were considered. The fuel savings the airlines could achieve right away under the present ATC system, and the reduction in fuel consumption that could be achieved under an improved air traffic control system assumed to be available in 1980. These effects on DOC's when fuel is at 30¢ per gallon are shown in Figure 27.

The benefits from an improved 1980 ATC environment are clearly visible. DOC's were reduced by 1-1/2 to 2-1/2 percent for the baseline aircraft. However, fuel savings achieved with improved flight operations under the present ATC system were not significant enough to result in DOC improvements at a fuel

TABLE 15

1973 DC-10-10 DOC COST COMPONENT COMPARISONS

DOC ELEMENTS ($ Per Blk Hr)	DAC	CAB DC-10-10	CAB / DAC	CAB DC-10-10 BY INDIVIDUAL CARRIER AA	CO	DL	NA	UAL	WA	Range
Crew	222	258	1.16	264	239	279	205	279	310	205-310
Fuel & Oil	257	281	1.09	285	282	292	269	278	298	269-298
Insurance	56	22	.39	12	23	25	36	24	23	12-36
Maintenance	(289)	(341)	1.18	(377)	(273)	(276)	(331)	(367)	(234)	234-377
Airframe	103	102	.99	109	71	101	88	124	66	66-124
Engine	74	112	1.51	129	107	44	132	106	77	44-132
Burden	112	127	1.13	139	95	131	111	137	91	91-139
Depreciation	366	423	1.16	401	288	866	322	450	358	288-866
TOTAL DOC ($ Per Blk Hr)	1190	1326	1.11	1338	1112	1737	1164	1397	1223	1112-1737
CAB DC-10-10 / Airline DC-10-10	--	1.00	--	0.99	1.19	0.76	1.14	0.95	1.08	0.76-1.19
DAC / Airline	0.90	--	--	0.89	1.07	0.69	1.02	0.85	0.97	0.69-1.07
OPERATING STATISTICS										
No. of Aircraft	--	62.8	--	22.8	7.0	4.9	9.0	17.4	1.7	--
Utilization (Hr/Yr)	3285	3370	--	3064	4090	3533	3702	3217	3829	3064-4090
Fuel (¢/Gal)	12.481	12.481	--	12.192	12.935	12.015	11.598	12.816	13.215	11.598-13.215
Average Stage (NM)	870	872	--	783	978	703	734	1076	1657	703-1657

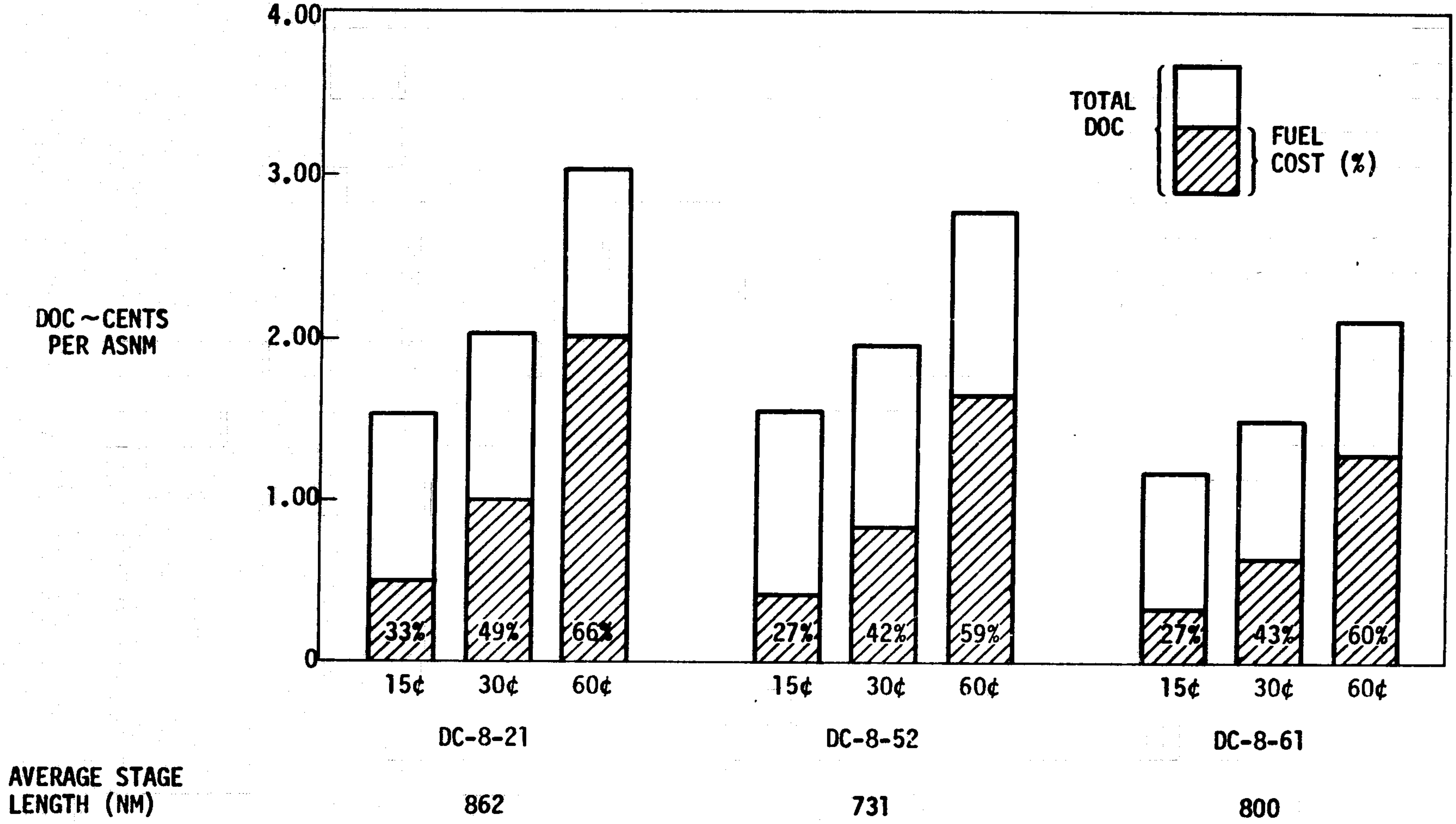


Figure 24. FUEL COST AS A PERCENT OF TOTAL DOC AT THREE FUEL PRICES - 15¢, 30¢, and 60¢ PER GALLON

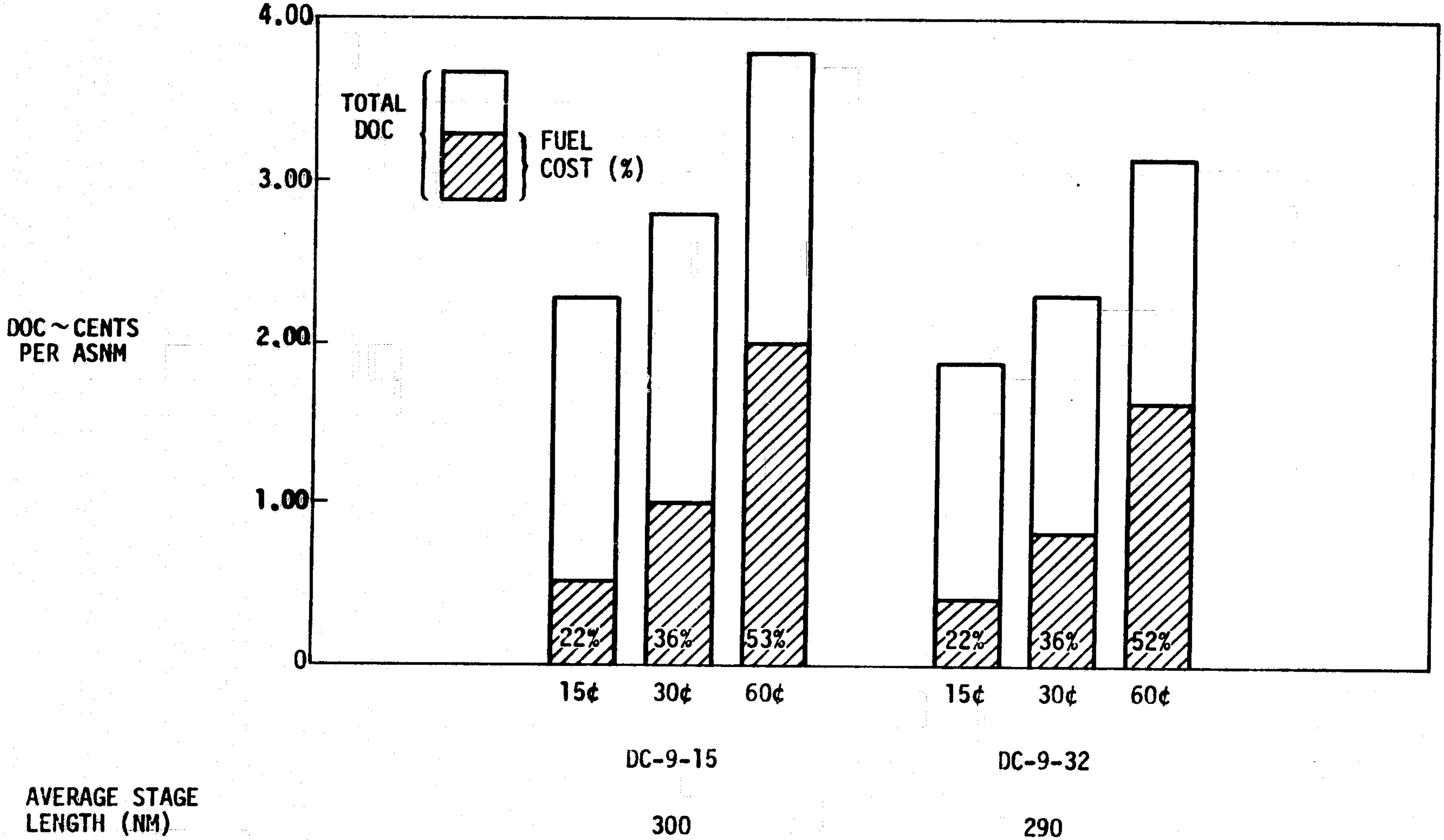


Figure 25. FUEL COST AS A PERCENT OF TOTAL DOC AT THREE FUEL PRICES - 15¢, 30¢, and 60¢ PER GALLON

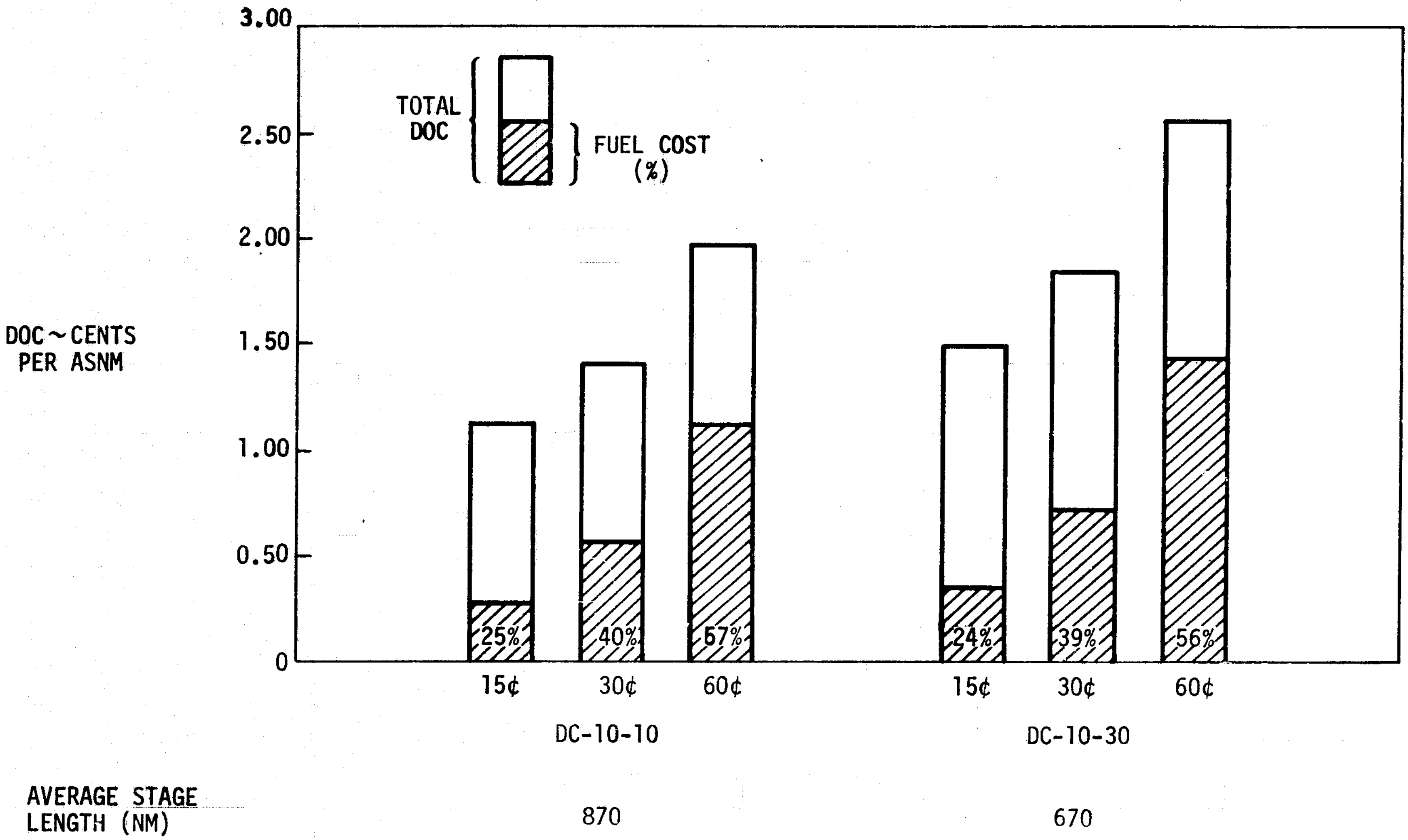


Figure 26. FUEL COST AS A PERCENT OF TOTAL DOC AT THREE FUEL PRICES - 15¢, 30¢, AND 60¢ PER GALLON

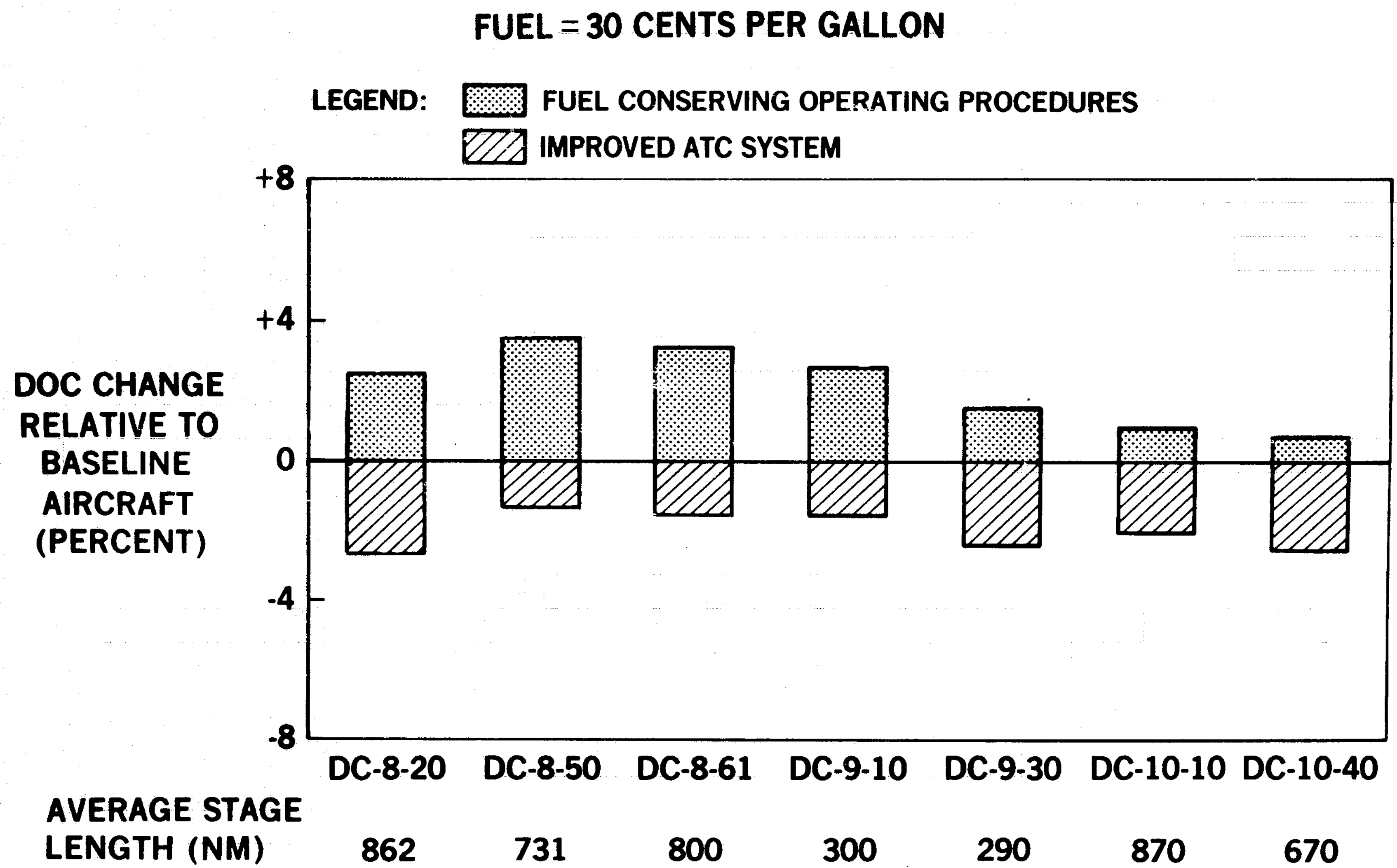


Figure 27. EFFECT OF FUEL-CONSERVATIVE OPERATIONS ON DOC

price of 30¢ per gallon. This situation was due to the increases in block times of 7 to 10 percent at the average stage length that resulted from the slowing down of the current baseline aircraft to conserve fuel.

With a fuel price of 60¢ per gallon, fuel savings from operational procedures under the present ATC system provide approximately a 1 percent DOC savings for the DC-9-30 and DC-10-10, and a little more than 1 percent for the DC-10-40. An improved 1980 ATC system results in DOC savings of between 3-1/2 to 5 percent for the baseline airplanes.

Figure 28 illustrates the effects on fuel burn, block time, and DOC's under the two levels of fuel conserving flight operations for the DC-9-30 and DC-10-10. For both aircraft, under the present ATC environment, block times increase significantly while fuel savings are not as large as under the improved 1980 ATC system. Therefore, in general, it takes a fuel price of 60¢ per gallon for the present improved flight operations considered here to pay off economically, even though there are fuel savings.

Seating Density - However, the most significant impact that can be made on fuel consumption at present is through increased seating density as shown in Table 16. The DC-10-10's seating density with a lower galley and an all coach configuration is increased by almost 6 percent while block fuel and DOC's are reduced by approximately 5 percent. The basic study DC-10-40's seating density with an upper galley is 9 percent less than the baseline DC-10-10. However, in an all tourist configuration with nine abreast seating, the DC-10-40 has about the same number of seats as the DC-10-10 with lower galleys. With this increased seating density of 17 percent, the DC-10-40 saved 13 percent in fuel and also reduced DOC's by about 14 percent.

While these increases in seating density can have a big impact initially, the improvements that are possible are eventually limited, and no fuel is saved if the seats do not carry more passengers. United Airlines, another contractor participating in the RECAT study, conducted a passenger survey on their route network which identified seating comfort as the most important aspect of flight. On the other hand, increased seating density was viewed as the least acceptable change by the passengers.

2.5.5 Selected Aircraft Options

For this discussion the aircraft options that were selected in the technical analysis for further study have been divided into two groups. The first

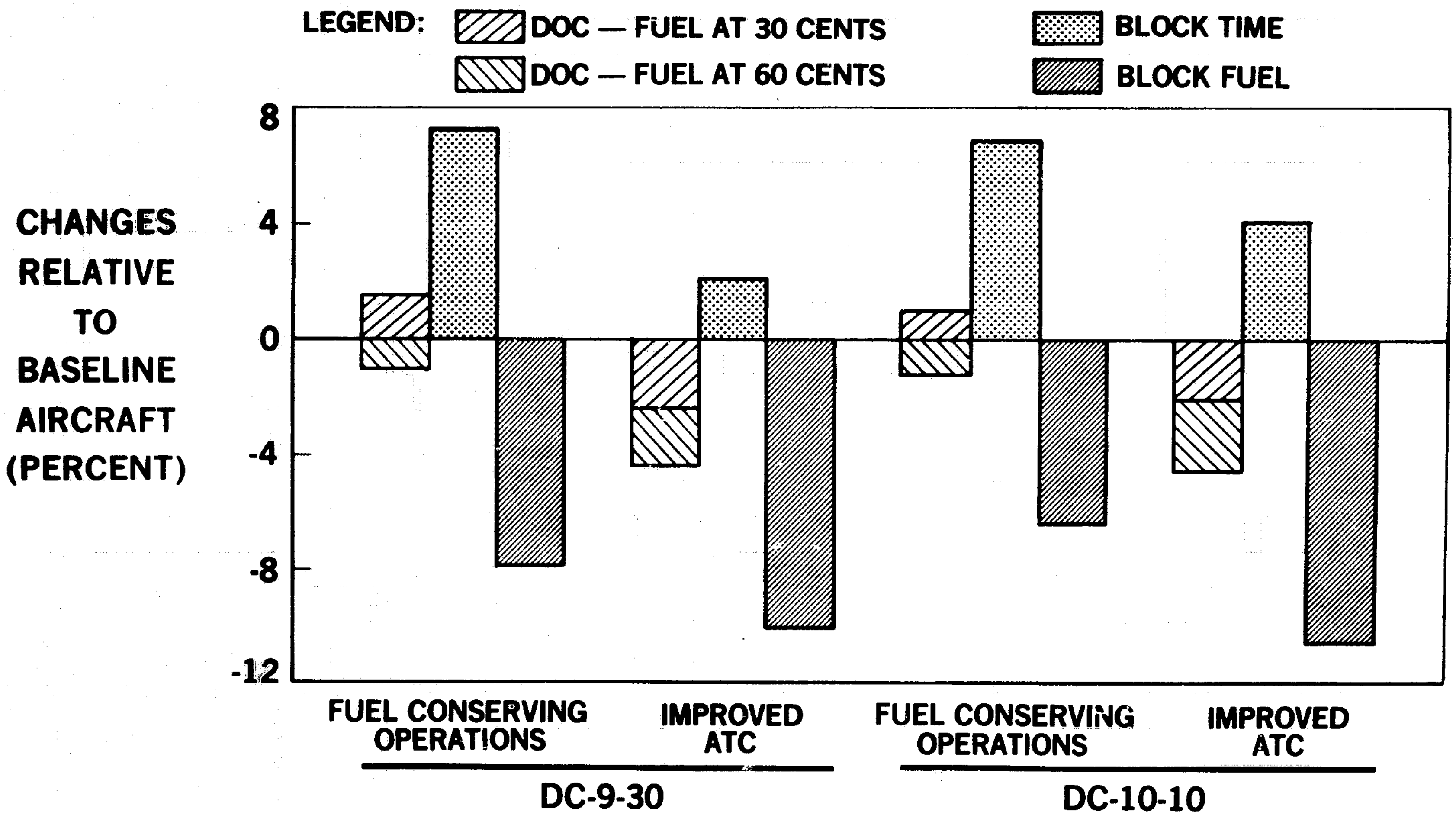


Figure 28. EFFECT OF OPERATIONAL CHANGES ON DOC, BLOCK FUEL AND TIME

At Average Stage Length (NM)

TABLE 16

EFFECT OF INCREASED SEATING DENSITIES ON BLOCK FUEL AND DOC AT 1973 CAB AVERAGE STAGE LENGTH

Aircraft	Seating Densities			Block Fuel Savings % (BTU Per ASNM)	DOC Improvement - % (¢ Per ASNM)		
	Baseline	Increased*	Increase (%)		@ 15¢/Gal	@ 30¢/Gal	@ 60¢/Gal
DC-8-20	146	159	+ 8.9	7.31	7.86	7.74	7.61
DC-8-50	146	159	+ 8.9	7.33	7.96	7.80	7.70
DC-8-61	203	218	+ 7.4	6.14	6.73	6.56	6.45
DC-9-10	70	77	+10.0	8.63	9.00	8.92	8.84
DC-9-30	92	105	+14.1	11.47	12.17	12.04	11.91
DC-10-10	277	293	+ 5.8	4.87	5.34	5.27	5.15
DC-10-40	252	295	+17.1	13.06	14.06	13.87	13.63

*Change 10/90 split to all tourist @ 34" pitch (on DC-10-40, also change seats from 8 to 9 abreast) group being those options related to the baseline existing airplanes and the second group comprising the all-new near-term 1980 aircraft.

Total DOC's and the cost components were tabulated for each aircraft option at the same stage lengths used in calculating the baseline aircraft DOC's. The direct operating costs are presented in terms of dollars per block hour ($/HR), dollars per nautical mile ($/NM), and cents per available seat-nautical mile (¢/ASNM). This information along with the corresponding block speeds for each airplane is included in the Appendix of this report.

2.5.6 Retrofit, Modification and Derivative Aircraft

The twenty options related to the baseline airplanes that were studied are listed in Table 17. Some special assumptions had to be made in order to calculate realistic DOC's for the retrofitted aircraft options.

TABLE 17

RETROFIT, MODIFICATION AND DERIVATIVE OPTIONS

Baseline Aircraft Type	Aircraft Designators*	Design Changes to Baseline Aircraft
DC-8-20/50/61	R	Aerodynamic and engine retrofit
	DR	Aerodynamic retrofit
	ER	Engine retrofit
DC-9-10/30	R	Aerodynamic retrofit
	D1	Stretched DC-9-30 (117 seats)
	D2	Stretched DC-9-30 (122 seats)
	D3	DC-9-30 with supercritical wing
DC-10-10/40	R	Aerodynamic retrofit
	M	Aerodynamic modification
DC-10-10	D	Shortened DC-10-10 (199 seats)
DC-10-40	D	Stretched DC-10-40 (327 seats)

*R, DR, ER = Retrofit, M = Modification, D = Derivative

Retrofit Aircraft Depreciation - Groundrules for the study DOC equations assumed a depreciable life for all aircraft options of sixteen years. However, in the case of the retrofitted airplanes, another depreciation schedule was developed to assure airline realism. Retrofits were modifications added to existing baseline aircraft that were already in service. The retrofit aircraft options were treated in this study as though the baseline airplanes had been sold and the new owner-operator was evaluating the economic and operational improvements possible with airplanes having the retrofit options As shown in Table 17, the retrofit aircraft options included aerodynamic improvements such as winglets and/or the installation of new engines.

A peak introduction year was established for each baseline aircraft type to which the retrofits were to be added. An average age at the time of retrofitting, in 1978 or 1979, was determined for each aircraft option. A minimum five year depreciation period was assumed for the retrofits unless the baseline airplane's remaining depreciable life prior to retrofitting was longer. In this case, the years remaining from the original depreciation period were assumed for the retrofit options. The depreciation periods used for each of the thirteen retrofits are given in Table 18.

In discussions with the airlines, it was noted that a five year payback period for the retrofit options on primarily the older DC-8's is extremely generous, especially for an aerodynamic retrofit. Recently, the airlines in evaluating their own retrofit options have been faced with required one to three year payback periods by their lenders. This financial condition is not particularly conducive to the airlines for retrofitting the current aircraft in their fleets.

Comparative Direct Operating Costs - The DOC's for the retrofit, modification and derivative aircraft options were compared to those of the baseline aircraft at fuel prices of 30¢ and 60¢ per gallon. Results of these comparisons in terms of cents per available seat nautical mile at the 1973 CAB average stage length are shown in Figures 29 and 30. As might be expected, when fuel price increases from 30¢ (Figure 29) to 60¢ per gallon (Figure 30) more aircraft options become economically attractive than with 30¢ fuel.

Figures 31 - 34 compare the fuel savings for each aircraft option against its improvement in DOC (¢/ASNM) at fuel prices of 30¢ and 60¢ per gallon.

TABLE 18

DEPRECIABLE LIFE FOR AIRCRAFT RETROFITS

AIRCRAFT TYPE	PEAK AIRCRAFT INTRODUCTION YEAR	RETROFIT INTRODUCTION YEAR	AVERAGE AIRCRAFT AGE IN INTRODUCTION YEAR	DEPRECIABLE LIFE
DC-8-20R/DR/ER	1960	1979	19 Years	5
DC-8-50R/DR/ER	1962	1979	17 Years	5
DC-8-61R/DR/ER	1968	1979	11 Years	5
DC-9-10R	1966	1978	12 Years	5
DC-9-30R	1968	1978	10 Years	6
DC-10-10R	1972	1978	6 Years	10
DC-10-40R	1973	1978	5 Years	11

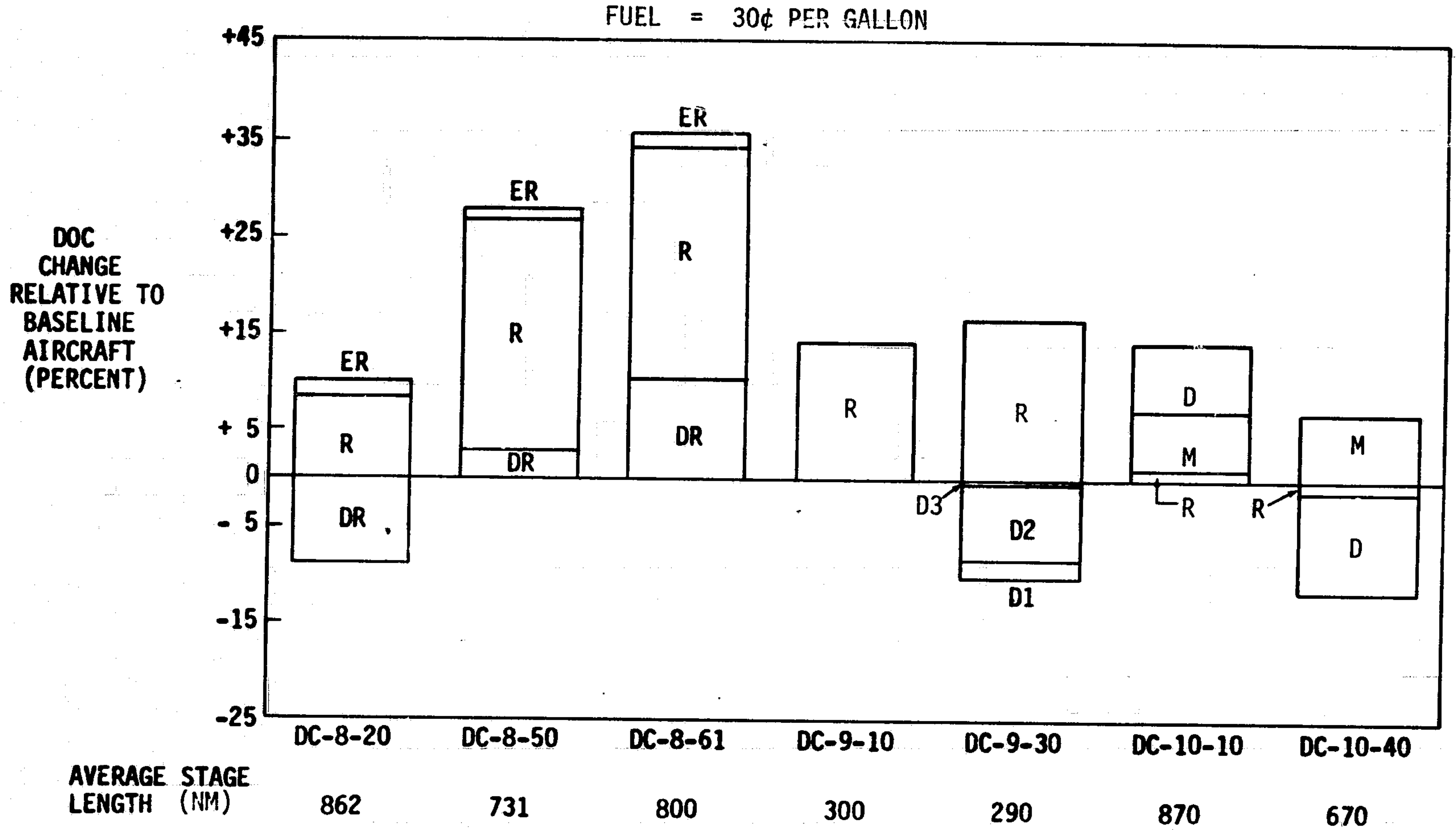


Figure 29. RETROFITS, MODIFICATIONS AND DERIVATIVES - DOC CHANGE (PERCENT)

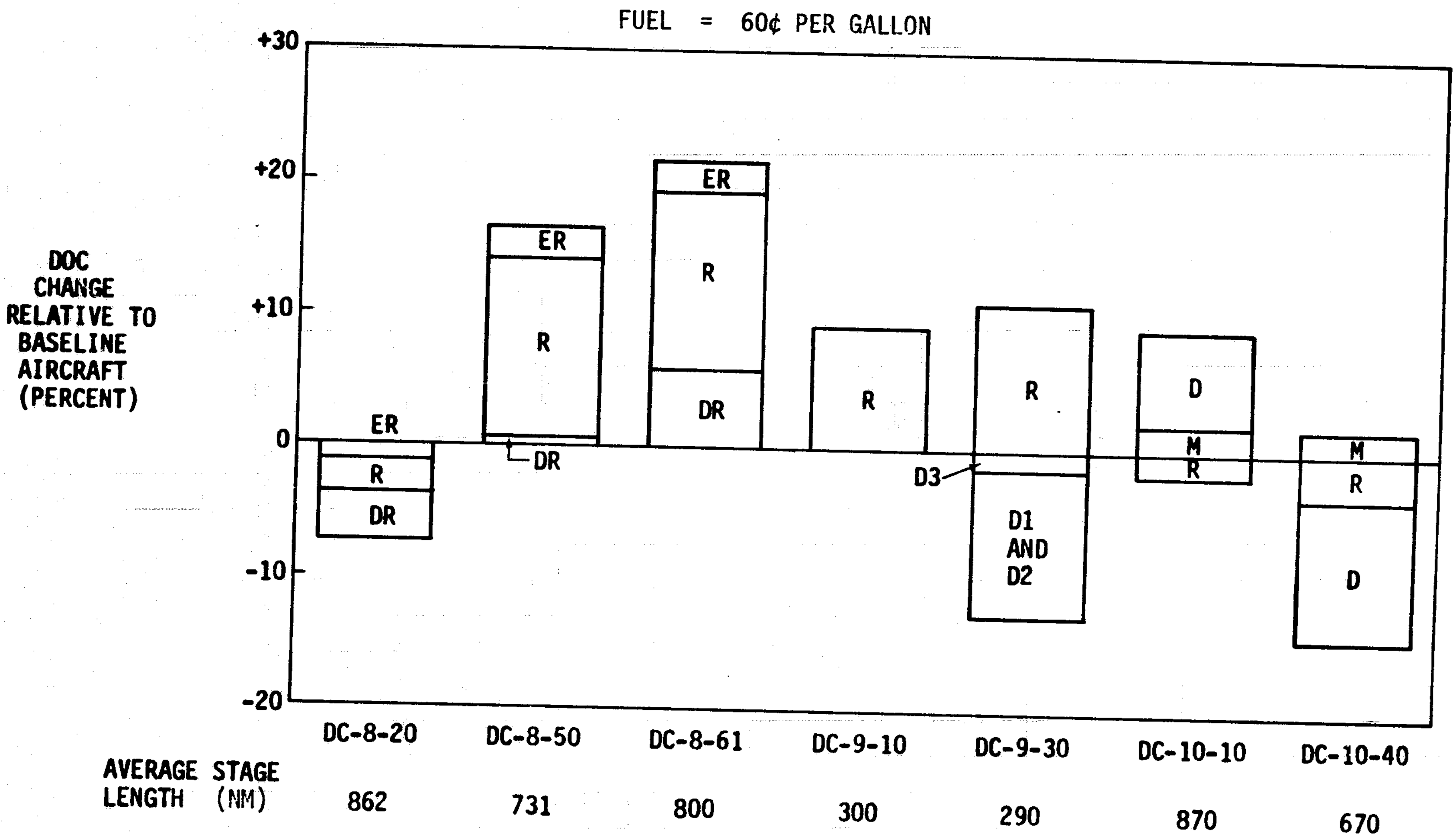


Figure 30. RETROFITS, MODIFICATIONS AND DERIVATIVES - DOC CHANGE (PERCENT)

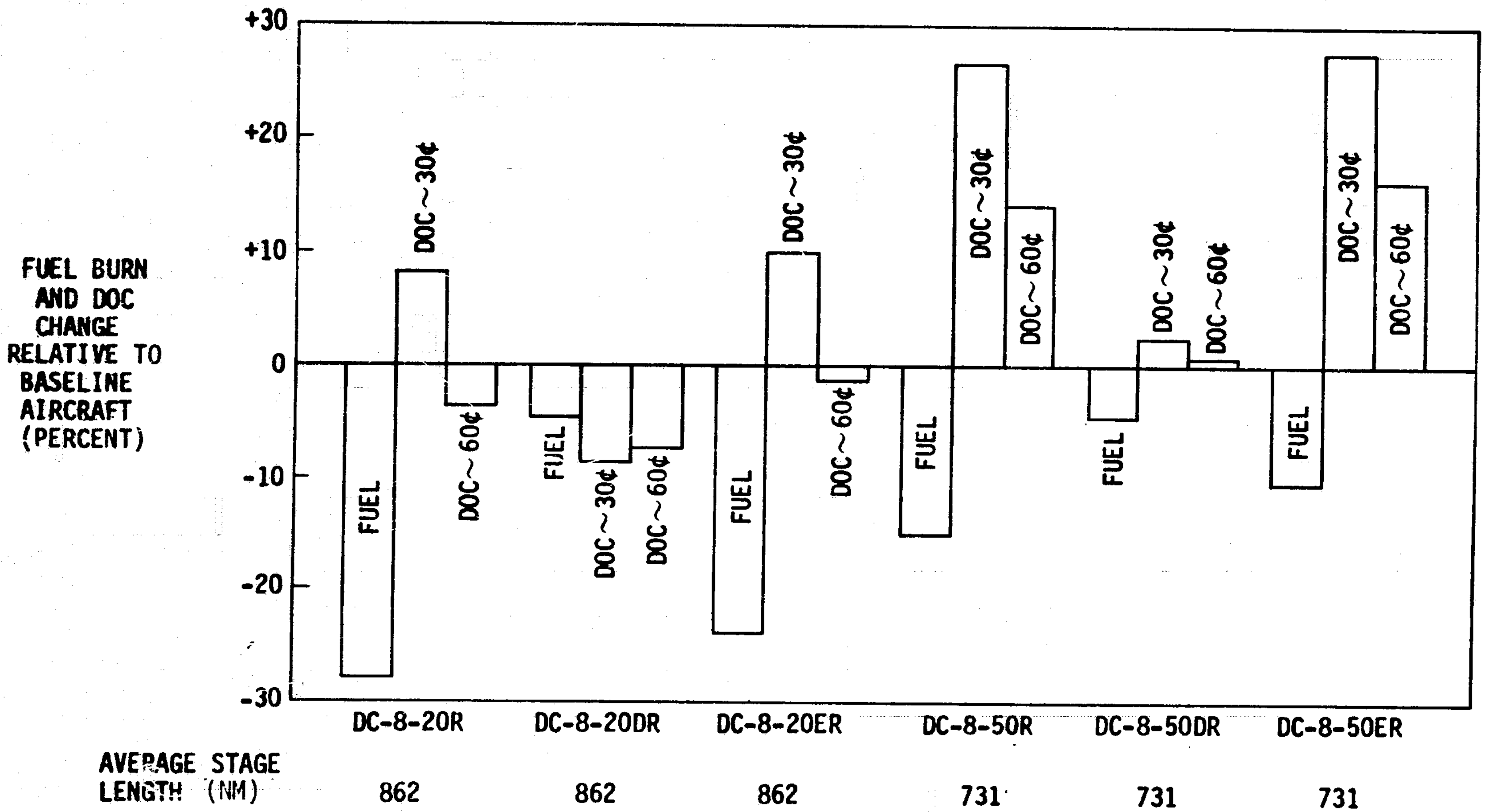


Figure 31. DC-8-20 AND DC-8-50 RETROFITS - FUEL BURN vs. DOC CHANGE (PERCENT)

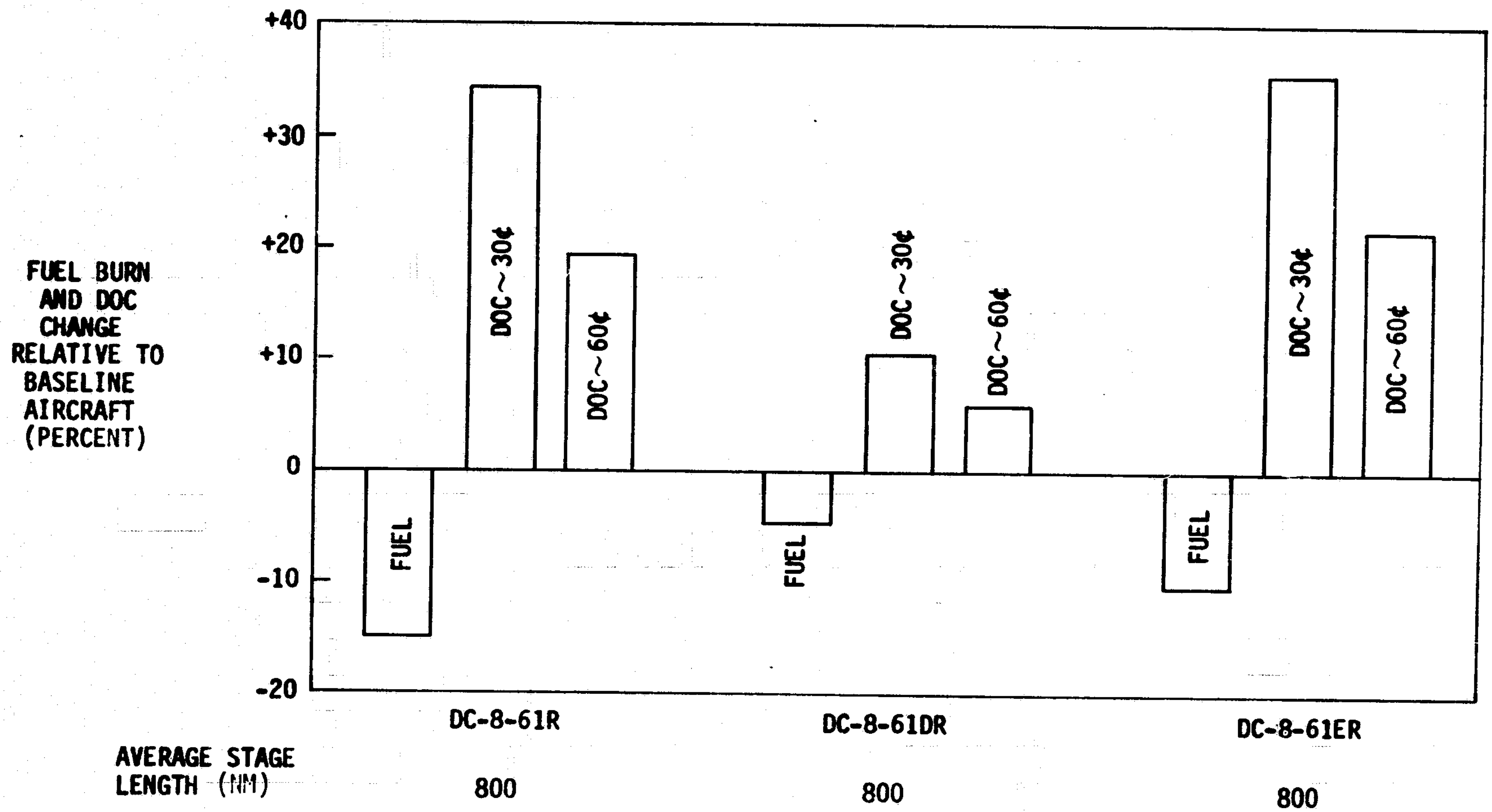


Figure 32. DC-8-61 RETROFITS - FUEL BURN vs. DOC CHANGE (PERCENT)

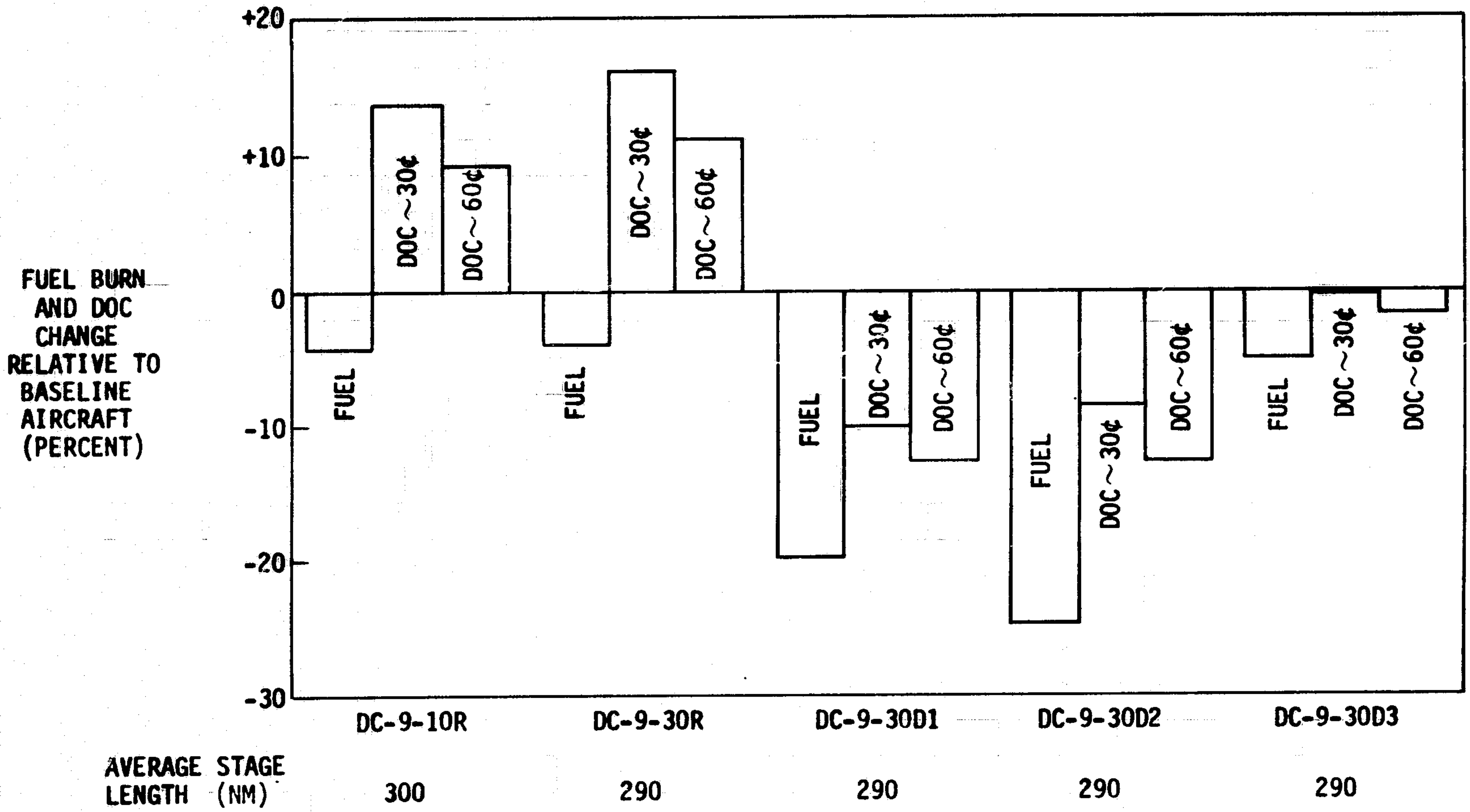


Figure 33. DC-9 RETROFITS AND DERIVATIVES - FUEL BURN vs. DOC CHANGE (PERCENT)

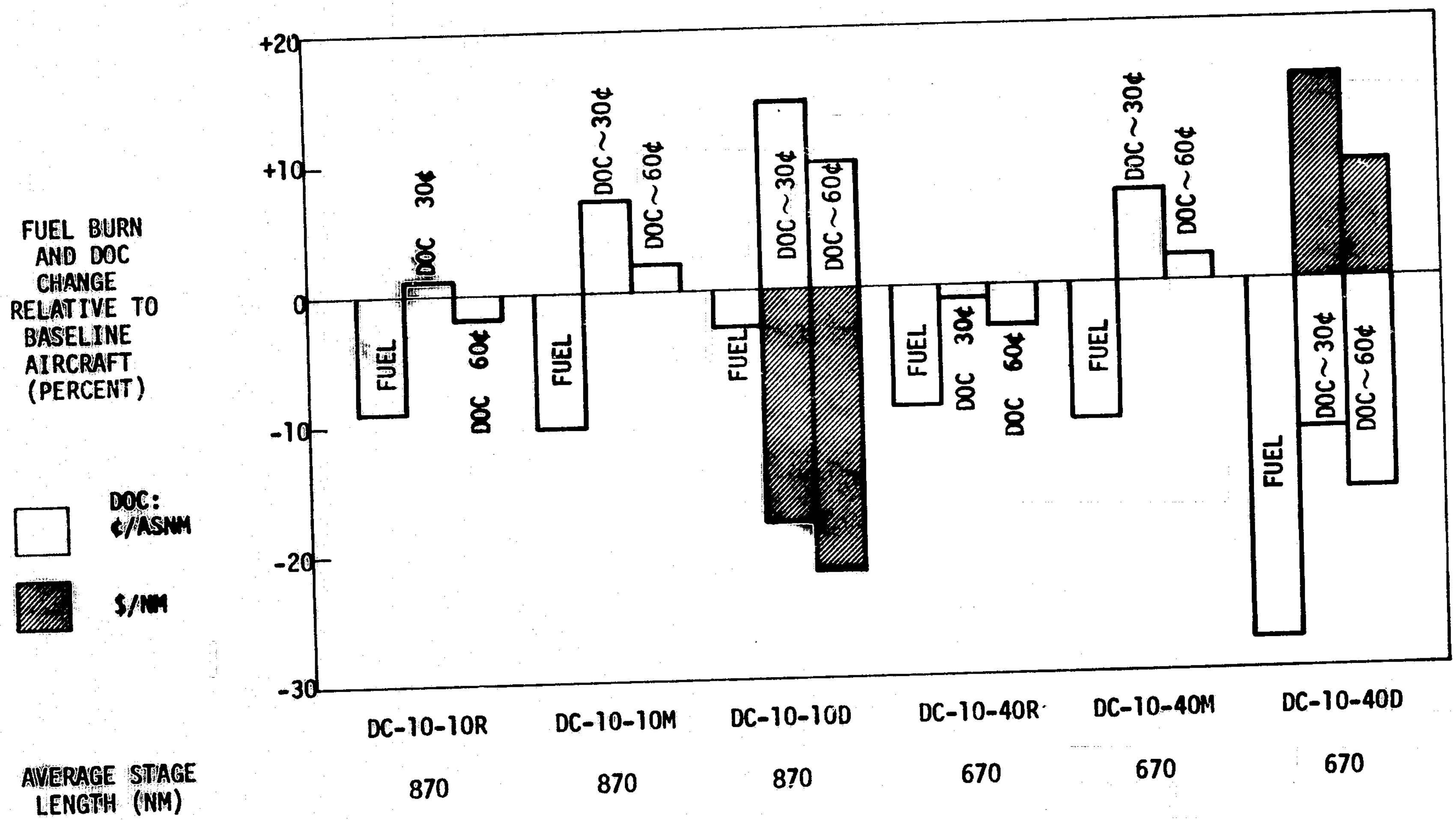


Figure 34. DC-10 RETROFITS AND DERIVATIVES - FUEL BURN VS. DOC CHANGE (PERCENT)

DC-8 Aircraft Options - The aerodynamic retrofits on the older DC-8's offer the greatest feasibility for retrofitting. The new engine retrofits and the retrofits combining a new engine and aerodynamic improvements do not appear to be economically viable options. This is due to the cost of the new engines at $2.64 million, as well as the expense of modifying the airframe to accept the engines, approximately $2 million for each DC-8 model. The aerodynamic retrofits on each of the DC-8 aircraft studied offer fuel savings of approximately 4-1/2 percent. However, the economic impact of this retrofit on the DOC's of each model is quite different. There is a sizeable reduction in DOC's for the DC-8-20, a modest increase in DOC's for the DC-8-50, and a sizeable increase in DOC's for the DC-8-61.

It should be pointed out, however, that the economic viability of each of the retrofit options is strongly dependent on the groundrules assumed in calculating the DOC's. This includes the assumption that the aircraft has been sold to a new owner who is evaluating the feasibility of retrofitting the aircraft. If it had been assumed that the original owner was retrofitting and keeping these airplanes in scheduled service, then the aerodynamic retrofits would all become economically viable.

However, the original owner might feel that by forestalling the purchase of new equipment, he should establish a sinking fund to reserve money for the future purchase of new equipment. This reserve account would include the anticipated effect of inflation on new aircraft prices at the time he is ready to retire the retrofitted option from service. Under these assumptions, some of the aerodynamic retrofits become less attractive again. Therefore, although some aircraft options using the groundrules established for the study are very viable both in terms of fuel and DOC savings, only an individual airline can effectively analyze these options based on their own operational and economic policies.

DC-9 Aircraft Options - The retrofits studied on the DC-9-10 and DC-9-30 airplanes did not offer significant fuel savings and sizeably increased DOC's at both fuel prices. On the other hand, the three DC-9-30 derivative models all provided significant fuel savings as well as a reduction in DOC's. Since the difference in seating density between the DC-9-30D1, 117 seats, and the

DC-9-30D2, 122 seats, was so small, the comparative viability of these two derivatives was determined by the market during the fleet forecasting phase of the study which is presented in Section 3.0.

DC-10 Aircraft Options - Under the groundrules assumed in this study, the DC-10 aerodynamic retrofits do appear to be economically viable. They offer significant fuel savings, approximately 9 percent, with a modest improvement in DOC's with fuel at 60 cents per gallon. The DC-10 modification options do offer fuel savings but not enough to offset the resulting increase in DOC's.

In assessing the viability of the DC-10 derivatives, a first glance at Figure 34 shows the DC-10-40D to be a very viable aircraft option. However, care must be taken in analyzing the DOC charts. If the DC-10-10D and DC-10-40D are replotted in terms of dollars per nautical mile, the picture changes importantly since the seats on these derivative models of the baseline aircraft vary substantially. The DC-10-10D has been shortened to carry 200 seats against the baseline DC-10-10 with 277 seats. The stretched DC-10-40D was configured for 327 seats as compared with 252 for the baseline DC-10-40.

Viewing the DOC's of the DC-10 derivative options in terms of dollars per nautical mile removes the effect of seat density biases. Then the DC-10-10D, the shortened DC-10, becomes a very viable option with a 30 percent improvement in fuel burned per nautical mile and a substantial reduction in DOC's over the baseline DC-10-10. On the other hand, fuel savings per nautical mile for the DC-10-40D were not significant enough at 6 percent to offset the resulting large increase in DOC's per nautical mile.

2.5.7 New Near-Term (1980) Aircraft

Three families of all new 1980 technology airplanes were studied. The first family included four airplanes designed to carry 200 passengers at a maximum range of 1,500 nautical miles. The second and third families of four aircraft each were configured for 200 and 400 passengers respectively, with maximum design ranges of 3,000 nautical miles. One aircraft in each of the three families was optimized specifically to meet one of the following four criteria:

- Minimum DOC at a fuel price of 15 cents per gallon:
  N80-2.15$_{15}$, N80-2.30$_{15}$, N80-4.30$_{15}$
- Minimum DOC at a fuel price of 30 cents per gallon:
  N80-2.15$_{30}$, N80-2.30$_{30}$, N80-4.30$_{30}$
- Minimum DOC at a fuel price of 60 cents per gallon:
  N80-2.15$_{60}$, N80-2.30$_{60}$, N80-4.30$_{60}$
- Minimum fuel burned:
  N80-2.15$_{MF}$, N80-2.30$_{MF}$, N80-4.30$_{MF}$

A major impact of fuel costs on new aircraft design is in aircraft speed. The higher the fuel cost, the slower the airplane cruises to achieve minimum direct operating costs, and consequently, the more fuel saved. The airplanes in each family optimized for minimum fuel consumption operated significantly slower than those airplanes optimized for a fuel price as high as 60 cents per gallon. The impact of this lower cruise Mach number on fuel savings is impressive, about 20 percent greater than for an aircraft optimized for minimum DOC's at a fuel price of 60 cents per gallon. However, the competitiveness of aircraft with such slow cruise speeds in an airline operating environment is greatly reduced as shown in the fleet forecast results presented in Section 3.0. With a cruise Mach number near 0.70, aircraft productivity decreases substantially over an airplane with a cruise Mach number of 0.80 or 0.85, frequencies decline, and passengers are turned away.

<u>Comparative Direct Operating Costs</u> - DOC's for the optimized aircraft within each family are compared in Table 19 at various stage lengths and a fuel price of 30 cents per gallon. With fuel at this price, the airplanes within each family optimized for minimum direct operating costs at a fuel price of 30 cents per gallon (N80-2.15$_{30}$, N80-2.30$_{30}$, and N80-4.30$_{30}$) will obviously have the lowest DOC's, as shown in the table. It should also be noted that the DOC's for all the aircraft optimized for minimum DOC's are very nearly the same.

TABLE 19

COMPARATIVE DIRECT OPERATING COSTS (CENTS PER ASNM)

FUEL = 30¢ PER GALLON

Aircraft Family	Stage Length (Nautical Miles)			
	500	1,000	1,500	3,000
N80 - 2.15 (200 Psgrs, 1,500 NM)				
2.15_{15}	1.72	1.47	1.39	--
2.15_{30}	1.70	1.46	1.38	--
2.15_{60}	1.72	1.47	1.39	--
2.15_{MF}	1.80	1.54	1.46	--
N80 - 2.30 (200 Psgrs, 3,000 NM)				
2.30_{15}	1.92	1.60	--	1.43
2.30_{30}	1.91	1.60	--	1.43
2.30_{60}	1.91	1.62	--	1.45
2.30_{MF}	1.99	1.72	--	1.54
N80 - 4.30 (400 Psgrs, 3,000 NM)				
4.30_{15}	1.39	1.18	--	1.05
4.30_{30}	1.39	1.17	--	1.04
4.30_{60}	1.40	1.17	--	1.04
4.30_{MF}	1.50	1.28	--	1.14

However, the DOC's for the airplanes optimized for minimum fuel consumption are between 6 and 10 percent higher than for the airplanes optimized for DOC's at 30 cents per gallon at the maximum design ranges. When fuel is at 60 cents per gallon, the DOC's for the minimum fuel airplanes are between 3 and 6 percent higher than for the airplanes designed for minimum DOC's at 60 cents per gallon, as shown in Table 20.

These two tables illustrate that as fuel price increases, the direct operating costs of an airplane optimized for minimum DOC's and one optimized for minimum fuel consumption approach each other. At some higher fuel price, the DOC's for both aircraft types will be equal.

Relative to Baseline Aircraft - The direct operating costs of the new near-term (1980) airplanes were compared with the DOC's of several baseline airplanes as shown in Figure 35. These comparisons were made at one third the design ranges of the N80 airplanes since the typical average stage lengths of current aircraft in domestic operations are approximately one third of their design ranges.

The N80-2.15 family, designed for a maximum range of 1,500 nautical miles, is compared with the DC-9-30 and DC-10-10 at 500 nautical miles. The DC-9-30 has 92 seats and a maximum range with full payload of 1,220 nautical miles, while the DC-10-10 has 277 seats and a range of 3,415 nautical miles. In terms of cents per available seat nautical mile, the N80-2.15 family's DOC's are between 10 and 15 percent lower than those of the DC-9-30 and between 5 and 10 percent higher than those of the DC-10-10.

DOC's for the N80-2.30 family with a maximum design range of 3,000 nautical miles were compared at 1,000 nautical miles against those of the DC-8-61. The baseline DC-8-61 has a comparable number of seats, 203, and a design range of 3,250 nautical miles. This family's DOC's were also compared to those of the DC-10-10 with 277 seats and a maximum range of 3,415 nautical miles. In both comparisons, DOC's in terms of cents per available seat nautical mile for the N80-2.30 airplanes were considerably higher than those for the DC-8-61 (between 12 and 20 percent higher) and for the DC-10-10 (between 18 and 26 percent higher). Since the N80-2.30 airplanes and the DC-8-61 were comparable in seating capacity, fuel savings of between 20 and

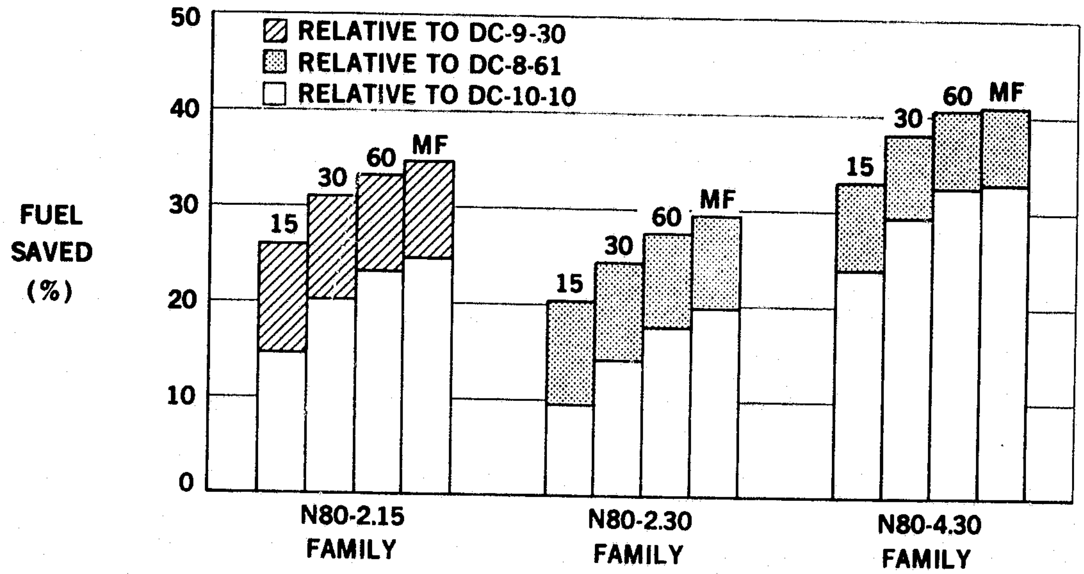
TABLE 20

COMPARATIVE DIRECT OPERATING COSTS (CENTS PER ASNM)

FUEL = 60¢ PER GALLON

Aircraft Family	Stage Length (Nautical Miles)			
	500	1,000	1,500	3,000
N80 - 2.15 (200 Psgrs, 1,500 NM)				
2.15_{15}	2.25	1.94	1.84	--
2.15_{30}	2.20	1.90	1.80	--
2.15_{60}	2.20	1.89	1.79	--
2.15_{MF}	2.27	1.94	1.84	--
N80 - 2.30 (200 Psgrs, 3,000 NM)				
2.30_{15}	2.49	2.10	--	1.91
2.30_{30}	2.45	2.08	--	1.88
2.30_{60}	2.44	2.07	--	1.87
2.30_{MF}	2.52	2.16	--	1.94
N80 - 4.30 (400 Psgrs, 3,000 NM)				
4.30_{15}	1.85	1.60	--	1.46
4.30_{30}	1.83	1.55	--	1.42
4.30_{60}	1.82	1.54	--	1.40
4.30_{MF}	1.92	1.64	--	1.49

A. COMPARISON OF FUEL SAVINGS (BTU/ASNM) AT 1/3 DESIGN RANGE



B. COMPARISON OF DOC (¢/ASNM) AT 1/3 DESIGN RANGE AND 30¢/GALLON FUEL PRICE

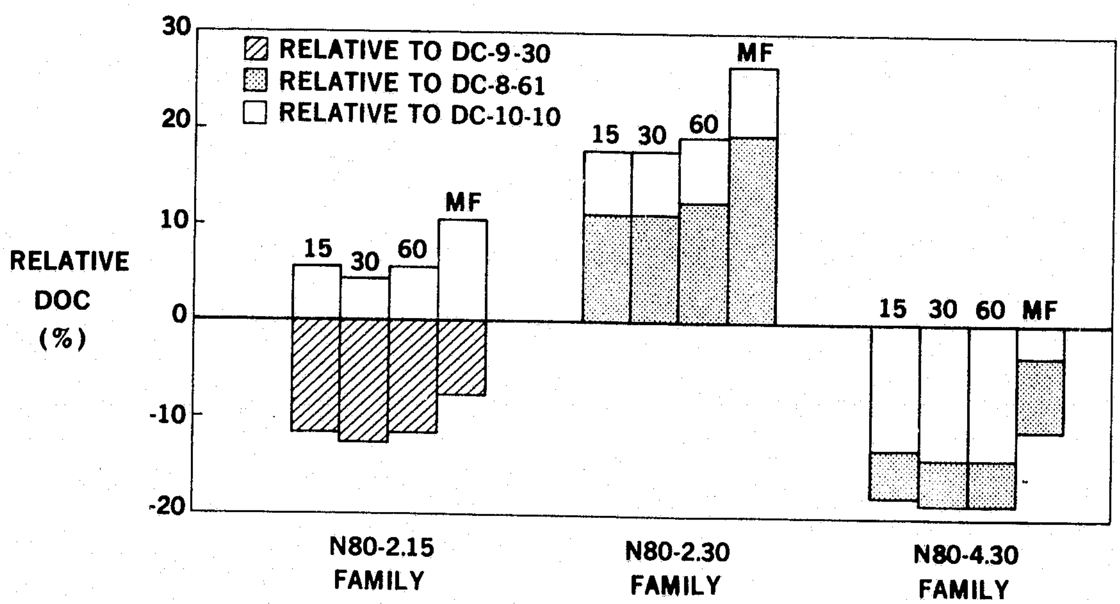


FIGURE 35. NEW NEAR-TERM AIRCRAFT FUEL SAVINGS AND DOC COMPARISON

29 percent for the N80-2.30 family were not enough to offset the effect of a total aircraft price of between 76 and 81 percent higher than the DC-8-61 on the DOC accounts. However, the DC-10-10 carried an extra 77 seats relative to the N80-2.30 airplanes, and in terms of dollars per nautical mile, DOC's for the N80-2.30 family are between 9 and 15 percent lower than for the DC-10-10.

The direct operating costs for the N80-4.30 family with a maximum design range of 3,000 nautical miles were also compared to the DOC's of the baseline DC-8-61 and DC-10-10 airplanes. The DOC's for the N80-4.30 family in terms of cents per available seat nautical mile were significantly lower than those of the DC-8-61 (between 6 and 14 percent lower) and of the DC-10-10 (between 11 and 19 percent lower) primarily due to the large differences in seating capacity.

<u>Relative to Derivative Aircraft Options</u> - Further DOC comparisons for the N80 aircraft were made with those of the derivative aircraft options as shown in Table 21. Several conclusions are apparent from the chart.

First, the N80-2.15$_{30}$ airplanes DOC's are 7 percent lower than those of the DC-10-10D at a stage length of 500 nautical miles. However, it should be emphasized that the relatively long-range DC-10-10D is being compared at 500 nautical miles to an aircraft optimized for operations at short stage lengths. In comparing the N80-2.15$_{30}$ to aircraft having more compatible design ranges, namely the DC-9-30 and DC-9-30D1, the N80-2.15$_{30}$ has a considerable advantage in seat-mile economy because it carries more seats.

Secondly, it appears from the chart that the N80-2.30$_{30}$ airplane is not a viable aircraft option for an airline attempting to maximize profits. This airplane's DOC's are not competitive at a 1,000 nautical mile stage length with the DOC's of any of the baseline or derivative aircraft likely to be operating in the same markets as the N80-2.30$_{30}$.

Additionally, the N80-4.30$_{30}$ seat-mile DOC is substantially better than those for aircraft with half the seats, the DC-8-61 and DC-10-10D as well as the baseline DC-10-10 with only 70 percent of the seating capacity. Also the DOC's for the N80-4.30$_{30}$ airplane are 3 percent lower in dollars per nautical

TABLE 21

COMPARATIVE DIRECT OPERATING COSTS

Fuel = 30¢ Per Gallon

N80-2.15$_{30}$ (200 PSGRS, 1500 NM DESIGN RANGE)
At 1/3 Design Range - 500 Nautical Miles

Aircraft Type (Psgrs, Design Range)	DC-9-30 92, 1220 NM	DC-9-30D1 117, 1350 NM	DC-10-10 277, 3415 NM	DC-10-10D 199, 2900 NM
Relative DOC:				
$/NM	1.915	1.660	.759	.936
¢/ASNM	.876	.966	1.046	.926

N80-2.30$_{30}$ (200 PSGRS, 3000 NM DESIGN RANGE)
At 1/3 Design Range - 1000 Nautical Miles

Aircraft Type (Psgrs, Design Range)	DC-8-61 203, 3250 NM	DC-10-10 277, 3415 NM	DC-10-10D 199, 2900 NM
Relative DOC:			
$/NM	1.106	.853	1.053
¢/ASNM	1.117	1.175	1.042

N80-4.30$_{30}$ (400 PSGRS, 3000 NM DESIGN RANGE)
At 1/3 Design Range - 1000 Nautical Miles

Aircraft Type (Psgrs, Design Range)	DC-8-61 203, 3250 NM	DC-10-10 277, 3415 NM	DC-10-10D 199, 2900 NM	DC-10-40D 327,4870 NM
Relative DOC:				
$/NM	1.615	1.245	1.537	.967
¢/ASNM	.812	.854	.757	.783

mile and almost 22 percent lower in cents per available seat nautical mile than the DOC's of the DC-10-40D. Here again it should be noted that not only was the $N80\text{-}4.30_{30}$ designed for a range of 3,000 nautical miles versus 4,870 nautical miles for the DC-10-40D, but also the $N80\text{-}4.30_{30}$ has about 23 percent more seats than the DC-10-40D.

Selection of Aircraft Options on the Basis of DOC - As can be seen, DOC comparisons on a consistent basis were difficult, since an aircraft with lower direct operating costs than a competitive aircraft option in terms of dollars per nautical mile, often had higher DOC's in terms of cents per available seat nautical mile or vice versa. Therefore, the relative ranking of the aircraft options with respect to DOC's alone would be inconclusive primarily because aircraft with unequal capabilities are being compared. They have widely varying design ranges as well as seating capacities. Also, it should be noted that the N80 airplanes were designed to carry only a full passenger payload plus baggage, while the baseline airplanes and the derivative options were sized to carry cargo as well. Additionally, fuel savings achieved by the N80's were based on cruise climb procedures rather than step altitude profiles. Since cruise climb is more fuel efficient than the step altitude profiles used for the baseline and derivative airplanes, fuel savings from the N80 aircraft are larger than would have been achieved with the presently more realistic step altitude profiles.

Selection of Aircraft Options Based Upon Market Requirements - Basically, the DOC data in Table 21 illustrates the fact that to realistically evaluate the DOC improvement of one aircraft over another involves comparing the economic and operational performance of each aircraft in a particular market. Also an airline's route structure could determine the selection of one aircraft type over another. For instance, an airline with a predominance of short-haul routes would most likely find the N80-2.15 family to be more economic than a DC-10-10. On the other hand, an airline with longer stage lengths would be limited to routes of 1,500 nautical miles or less with the N80-2.15. Therefore, the DC-10-10 might be less economic than the N80-2.15 on the short routes but much more economic on the medium and long-haul routes as well as optimal when operated within the airline's entire routing network. Consequently, all 32 selected aircraft options were allowed to prove their economic viability in the marketplace during the fleet forecasting phase of the study (Section 3.0).

2.6 Indirect Operating Costs

In contrast to the direct operating costs which are aircraft related, the majority of airline indirect operating costs are considered to be nonaircraft related. Rather these costs are viewed as airline system related. They are primarily traffic (passenger and/or cargo) dependent and are heavily influenced by management philosophy. Traffic related expenses vary with the traffic volume and are directly related to it. This includes the costs for food and beverage service, passenger and cargo liability insurance, traffic servicing, as well as reservations, sales, and sales commissions. The airline related costs are usually budgeted or predetermined annually by company management as a function of estimated revenue. These costs include advertising and publicity expenses as well as general and administrative costs. Since IOC's are so heavily traffic, revenue and airline related, the RECAT Study contractors and NASA agreed to use the 1969 Lockheed Committee IOC formula updated to 1973 cost levels. This allowed for the computation of comparable and consistent indirect operating costs for each aircraft studied.

2.6.1 Lockheed Committee IOC Method

The 1969 Lockheed IOC method was developed from the annual expense data and operating statistics reported to the Civil Aeronautics Board by the U.S. airlines. The CAB publishes this data in the Form 41 Schedules detailing indirect expenses by function or cost categories and objective accounts along with the related airline operating statistics, but not by aircraft type.

During development of the Lockheed IOC formula, each CAB indirect expense function was analyzed in detail and related to one or more appropriate airline operating statistic. In order to equitably distribute the indirect operating costs to all types of aircraft, the related operating parameters were established very carefully. Coefficients were developed which when applied to the selected operating statistics reasonably duplicated the U.S. domestic system's indirect operating expenses for the year 1969. These system IOC's represented the total IOC's for the eleven domestic airlines as reported to the CAB in 1969.

This IOC method produces average airplane costs and is intended as a basis of comparison between different aircraft types. Since costs calculated with this formula represents averages, they cannot be compared directly to actual cost data experienced by a particular carrier. Indirect operating costs for an individual airline are dependent upon its route structure, passenger traffic, aircraft types and fleet sizes, as well as its accounting procedures and management philosophy. Table 22 illustrates the wide spread of annual 1973 indirect operating costs among eight trunk and six local service carriers operating Douglas jet equipment in U.S. domestic service.

2.6.2 Comparison of CAB IOC Data with Lockheed IOC Method

CAB Cost Categories - The IOC functions or cost categories defined by the CAB are listed in Table 23. The Lockheed cost categories are similar but some variations were made in account groupings within each IOC function. This was done for those accounts that tended to vary with a common operating statistic. Table 24 gives the Lockheed cost categories and shows the relationship of the CAB IOC functions to these categories. Although each CAB function is included, several functions appear in more than one of the Lockheed cost categories illustrating the variation in objective account groupings.

TABLE 23

CAB INDIRECT OPERATING COST FUNCTIONS

5200 - Direct Maintenance - Ground Prop. & Equip.	6300 - Servicing Administration
5300 - Applied Maint. Burden - Ground Prop. & Equip.	6500 - Reservations & Sales
5500 - Passenger Service	6600 - Advertising & Publicity
6100 - Aircraft Servicing	6800 - General & Administrative
6200 - Traffic Servicing	7000 - Depreciation & Amort. - Ground Prop. & Equip.

Since the IOC's are considered traffic or airline related, the CAB Form 41 data is not broken down by aircraft type. However, controversy exists as to whether landing fees, cabin service expenses including cabin attendant costs as well as aircraft servicing expenses should not be considered aircraft related and possibly as elements of DOC. Historically these costs were very variable and as a convenience were treated as an annual airline cost as the CAB has done rather than related to a particular flight by equipment type.

TABLE 22

ANNUAL 1973 INDIRECT OPERATING EXPENSES BY AIRLINE

TRUNKS	ANNUAL IOC (MILLIONS)	PERCENT OF DOC	LOCAL SERVICE	ANNUAL IOC (MILLIONS)	PERCENT OF DOC
AMERICAN	$ 801.8	140	ALLEGHENY	$ 167.8	119
BRANIFF	165.7	124	HUGHES AIRWEST	71.3	136
CONTINENTAL	203.8	121	NORTH CENTRAL	68.4	149
DELTA	578.0	137	OZARK	43.9	125
EASTERN	606.1	139	SOUTHERN	42.4	106
NATIONAL	207.5	133	TEXAS INT'L.	40.6	120
NORTHWEST	176.5	82			
UNITED	977.3	120			
WESTERN	202.1	137			
TOTAL	$3,918.8	WTD. 128 AVG.	TOTAL	$ 434.6	WTD. 125 AVG.

SOURCE: CAB FORM 41 DATA FOR THE YEAR 1973

TABLE 24

COMPARISON OF STUDY IOC COST CATEGORIES VERSUS
CAB FORM 41 IOC FUNCTIONS

LOCKHEED INDIRECT OPERATING COST CATEGORIES	OBJECTIVE ACCOUNTS WITHIN THESE CAB IOC FUNCTIONS RELATED TO LOCKHEED IOC COST CATEGORIES
1. AIRCRAFT SYSTEM EXPENSES	5200 - Direct Maintenance - Ground Prop. & Equipment 5300 - Applied Maintenance Burden - Ground Prop. & Equipment 7000 - Depreciation and Amortization - Ground Prop. & Equipment
2. AIRCRAFT LOCAL EXPENSES	5200 - Direct Maintenance - Ground Prop. & Equipment 5300 - Applied Maintenance Burden - Ground Prop. & Equipment 6100 - Aircraft Servicing 6300 - Servicing Administration 7000 - Depreciation and Amortization - Ground Prop. & Equipment
3. AIRCRAFT CONTROL EXPENSES	6100 - Aircraft Servicing
4. CABIN ATTENDANT EXPENSE	5500 - Passenger Service
5. PASSENGER SERVICE	5500 - Passenger Service
6. PASSENGER HANDLING EXPENSE	6200 - Traffic Servicing 6500 - Reservations & Sales
7. CARGO HANDLING	6200 - Traffic Servicing
8. OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	5500 - Passenger Service 6500 - Reservations & Sales 6600 - Advertising & Publicity
9. FREIGHT COMMISSIONS AND ADVERTISING	6500 - Reservations & Sales 6600 - Advertising & Publicity
10. GENERAL AND ADMINISTRATIVE EXPENSES	6800 - General & Administrative

Impossibility of Direct Comparison - In defining a method to compare the economic viability of one aircraft to another, Lockheed found it appropriate to allocate some IOC expenses by aircraft type. Since the CAB Form 41 data is not in this format, it is not possible to directly compare the CAB IOC's with those calculated by the formula for each airplane studied. Also, the CAB allows the airlines great latitude in assigning and allocating expenses to the objective accounts within the various IOC functions or cost categories. Therefore, it would also be impossible to duplicate the IOC's for one particular carrier. However, use of the Lockheed IOC method is reasonable for this study in comparing aircraft options since the formula is representative of IOC's for the U.S. domestic system.

2.6.3 Updated Lockheed IOC Method

Recently the Lockheed California Company in Report COA 2061, July 1974, updated the IOC coefficients originally developed in 1969 to estimate 1973 cost levels. These coefficients were used in the study and represented the 1973 weighted average of the CAB Form 41 data for the U.S. domestic carriers. The 1973 Indirect Operating Cost equations used are given in Figure 36.

Assumptions in Using the Method - Lockheed and Douglas worked together in establishing a firm set of IOC assumptions for the study. These are documented in Figure 37. In using the Lockheed IOC method (Figure 36), the IOC's for a given aircraft would vary slightly with a change in fuel price since the general and administrative account is a function of DOC. However, realistically no variation in IOC expenses were anticipated as a result of higher fuel prices. Therefore this effect was ignored, and all IOC's were calculated based upon DOC's with a fuel price of 15 cents per gallon.

With an increase in load factor above the target of 58 percent, a slight increase could occur in several of the passenger service functions. However, since the resulting decrease in frequencies due to the higher load factors could lower some expenses and offset the increases in the passenger service areas, this effect on aircraft IOC's was also not considered in this study.

2.6.4 Baseline Airplanes and Selected Aircraft Options

The indirect operating costs (IOC's) for the baseline Douglas airplanes and the 32 selected aircraft options were calculated using the updated 1973 Lockheed formula. IOC's were determined at various stage lengths in terms of

1. AIRCRAFT SYSTEM EXPENSES: $0.51 \times DML$

2. AIRCRAFT LOCAL SERVICING EXPENSES: $1.47\ (TOGW \times 10^{-3})$

3. AIRCRAFT CONTROL EXPENSES: 19.49

4. CABIN ATTENDANT EXPENSE: $22.73\ (CC \times t_b)$

5. PASSENGER SERVICE: $1.12\ (PSGR \times t_b)$

6. PASSENGER HANDLING EXPENSE: $5.42 \times PSGR$

7. CARGO HANDLING: $75.68\ \left[CARGO\ TONS + \frac{PSGR \times 35}{2000}\right]$

8. OTHER PSGR SERVICE, COMMISSIONS AND ADVERTISING: $0.0037 \times RPM$

9. FREIGHT COMMISSIONS AND ADVERTISING: $0.0059 \times RTM$

10. GENERAL AND ADMINISTRATIVE EXPENSES: $0.053\ \left[(DOC-DEPRECIATION) + \sum_{1}^{9} \$\right]$

where:

DML	=	Direct Maintenance Labor ($)
TOGW	=	Max Takeoff Gross Weight (lb)
PSGR	=	Number of Passengers
DOC	=	Direct Operating Costs
CC	=	Number of Cabin Attendants
t_b	=	Block Time (hr)
RPM	=	Revenue Passenger-Miles
RTM	=	Revenue Tons-Miles

(1) Revision to 1969 Lockheed Indirect Operating Expense Method Report, COA 2061, Lockheed-California Company, July 1974

Figure 36. Indirect Operating Cost Equations (1)
1973 Dollars per Departure

- UPDATED LOCKHEED IOC COEFFICIENTS FOR U.S. DOMESTIC CARRIERS IN 1973 (REPORT NO. COA/1277, JUNE 1974)
- LOAD FACTOR 58 PERCENT
- FREIGHT CARRIED BASED ON UAL EXPERIENCED TONNAGE AT THE UAL DOMESTIC AVERAGE STAGE LENGTH BY AIRCRAFT TYPE
- CARGO REVENUE - 3 PERCENT OF TOTAL REVENUE GENERATED BY SCHEDULED PASSENGER SERVICE
- CARGO TONNAGE AND CABIN ATTENDANTS ASSUMED BY AIRCRAFT TYPE

	CABIN ATTENDANTS	CARGO TONS
DC-8-20/20R/20DR/20ER	5	.78
DC-8-50/50R/50DR/50ER	5	.78
DC-8-61/61R/61DR/61ER	6	.78
DC-9-10/10R	2	.46
DC-9-30/30R/30D3	3	.46
DC-9-30D1/30D2	4	.46
DC-10-10/10R/10M	8	2.60
DC-10-10D	6	2.60
DC-10-40/40R/40M	8	2.60
DC-10-40D	10	2.60
N80-2.15 FAMILY	6	1.95
N80-2.30 FAMILY	6	2.05
N80-4.30 FAMILY	11	3.40

- IOCs EXPECTED NOT TO VARY SIGNIFICANTLY WITH FUEL PRICE INCREASES

Figure 37. INDIRECT OPERATING COST ASSUMPTIONS - 1973 DOLLARS

dollars per block hour ($/HR), dollars per nautical mile ($/NM) and cents per available seat-nautical mile (¢/ASNM). An example of this IOC data is presented for the baseline DC-10-10 in Table 25. The IOC's for each baseline airplane were also tabulated by the major cost components in the Lockheed equations. The indirect operating cost categories in terms of cents per available seat nautical mile are given for the baseline airplanes in Tables 26-32. Additional IOC data for the baseline airplanes and all the aircraft options are given in the Appendix of this report.

Retrofit and Modification Options - It should be pointed out, however, that the IOC's for the airplane retrofits and modifications were virtually identical to those for their respective baseline airplanes. This occurred since no major changes had been made to these modified aircraft options, and their seating capacities and block times versus range remained the same as those for the baselines. The small differences in takeoff gross weights and possible direct engine maintenance labor costs hardly affected the total IOC's for the retrofits and modifications relative to their baselines. Therefore, for this study their IOC's were assumed equivalent to those of their respective baseline airplanes.

Table 33 compares the IOC's of the different aircraft types including the existing baseline airplanes and their derivatives at various stage lengths. As can be seen, IOC's did not vary significantly for similar aircraft types of approximately the same seating capacities. This is demonstrated by the DC-8-20 and DC-8-50 as well as the DC-9-30 and its three derivatives. IOC's for the DC-9-30D2, with the highest seating capacity of the DC-9 derivatives, were only 3 percent less at 500 nautical miles and less than 2 percent less at 1,500 nautical miles. The DC-9-30D2 has 30 more seats than the baseline DC-9-30 but carries only 17 more passengers at a 58 percent load factor.

The IOC's for the DC-10 baseline airplanes and their derivatives vary from the relationship established above. This is due to the large differences in the sizes of the aircraft resulting in differing takeoff gross weights, seating capacities, and the required number of cabin attendants on the derivative aircraft options. The DC-10-10D has 78 seats less than the baseline DC-10-10 while the DC-10-40D has 75 seats more than the baseline DC-10-40. These variations in seating capacities are directly related to passenger volume

TABLE 25

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

AVERAGE STAGE LENGTH - 870 NAUTICAL MILES

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	164	1512.33	9.23	3.33	3955.25	24.13	8.71
250	275	1386.55	5.05	1.82	2903.02	10.57	3.82
500	355	1295.85	3.65	1.32	2144.31	6.05	2.18
750	389	1256.28	3.23	1.17	1769.20	4.55	1.64
1,000	408	1231.68	3.02	1.09	1553.22	3.81	1.37
2,000	445	1200.83	2.70	.97	1192.33	2.68	.97
3,000	459	1197.69	2.61	.94	1057.38	2.30	.83
AVG. STAGE	399	1241.61	3.11	1.12	1652.37	4.14	1.49

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $18,300,000

FUEL COST = 15¢/GALLON

TABLE 26

DC-8-20 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 862 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	2000	3000	AVG. STAGE LENGTH
SYSTEM EXPENSE	.165	.081	.053	.044	.039	.032	.030	.042
LOCAL EXPENSE	2.779	1.112	.556	.371	.278	.139	.093	.322
AIRCRAFT CONTROL	.133	.053	.027	.018	.013	.007	.004	.016
CABIN ATTENDANT	.444	.274	.218	.198	.188	.174	.169	.193
FOOD AND BEVERAGE	.372	.230	.183	.166	.158	.146	.142	.162
PASSENGER HANDLING	3.155	1.262	.631	.421	.316	.158	.105	.366
CARGO HANDLING	1.174	.469	.235	.156	.118	.058	.039	.136
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.215	.215	.215	.215	.215	.215	.215	.215
FREIGHT COMMISSIONS AND ADVERTISING	.003	.003	.003	.003	.003	.003	.003	.003
GENERAL AND ADMINISTRATIVE EXPENSES	.610	.290	.186	.151	.134	.108	.099	.142
TOTAL IOC	9.050	3.989	2.307	1.743	1.462	1.040	.899	1.597

TABLE 27

DC-8-50 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 731 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	2000	3000	AVG. STAGE LENGTH
SYSTEM EXPENSE	.164	.082	.054	.045	.040	.033	.031	.045
LOCAL EXPENSE	3.021	1.208	.604	.403	.302	.151	.101	.413
AIRCRAFT CONTROL	.133	.053	.027	.018	.013	.007	.004	.018
CABIN ATTENDANT	.413	.265	.215	.198	.191	.178	.174	.199
FOOD AND BEVERAGE	.346	.222	.180	.166	.160	.149	.146	.167
PASSENGER HANDLING	3.155	1.262	.631	.421	.316	.158	.105	.432
CARGO HANDLING	1.174	.469	.235	.156	.118	.058	.039	.161
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.215	.215	.215	.215	.215	.215	.215	.215
FREIGHT COMMISSIONS AND ADVERTISING	.003	.003	.003	.003	.003	.003	.003	.003
GENERAL AND ADMINISTRATIVE EXPENSES	.617	.295	.186	.150	.132	.106	.096	.152
TOTAL IOC	9.241	4.074	2.350	1.775	1.490	1.058	.914	1.805

TABLE 28

DC-8-61 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 800 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	2000	3000	AVG. STAGE LENGTH
SYSTEM EXPENSE	.139	.067	.043	.035	.031	.025	.023	.034
LOCAL EXPENSE	2.353	.941	.471	.314	.235	.118	.078	.294
AIRCRAFT CONTROL	.096	.038	.019	.013	.010	.005	.003	.012
CABIN ATTENDANT	.396	.239	.188	.174	.166	.155	.150	.171
FOOD AND BEVERAGE	.384	.232	.182	.168	.161	.150	.145	.166
PASSENGER HANDLING	3.151	1.260	.630	.420	.315	.158	.105	.394
CARGO HANDLING	1.059	.424	.212	.141	.106	.053	.036	.133
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.215	.215	.215	.215	.215	.215	.215	.215
FREIGHT COMMISSIONS AND ADVERTISING	.002	.002	.002	.002	.002	.002	.002	.002
GENERAL AND ADMINISTRATIVE EXPENSES	.551	.257	.160	.128	.112	.088	.082	.124
TOTAL IOC	8.346	3.675	2.122	1.610	1.353	.969	.839	1.545

TABLE 29

DC-9-10 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 300 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	1250	1500	AVG. STAGE LENGTH
SYSTEM EXPENSE	.112	.067	.053	.048	.045	.044	.043	.062
LOCAL EXPENSE	1.905	.762	.381	.254	.190	.152	.127	.635
AIRCRAFT CONTROL	.278	.111	.056	.037	.028	.022	.019	.093
CABIN ATTENDANT	.351	.223	.184	.171	.162	.159	.156	.210
FOOD AND BEVERAGE	.354	.226	.186	.172	.164	.160	.157	.212
PASSENGER HANDLING	3.175	1.270	.635	.423	.317	.254	.212	1.058
CARGO HANDLING	1.273	.509	.255	.169	.127	.102	.084	.424
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.217	.217	.217	.217	.217	.217	.217	.217
FREIGHT COMMISSIONS AND ADVERTISING	.004	.004	.004	.004	.004	.004	.004	.004
GENERAL AND ADMINISTRATIVE EXPENSES	.571	.283	.187	.155	.139	.130	.123	.251
TOTAL IOC	8.240	3.672	2.158	1.650	1.393	1.244	1.142	3.166

TABLE 30

DC-9-30 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 290 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	1,250	1,500	AVG. STAGE LENGTH
SYSTEM EXPENSE	.101	.058	.043	.039	.036	.035	.034	.054
LOCAL EXPENSE	1.726	.690	.345	.230	.173	.138	.115	.595
AIRCRAFT CONTROL	.212	.085	.042	.028	.021	.017	.014	.073
CABIN ATTENDANT	.408	.261	.209	.195	.187	.181	.178	.245
FOOD AND BEVERAGE	.355	.227	.182	.169	.163	.158	.155	.214
PASSENGER HANDLING	3.122	1.249	.624	.416	.312	.250	.208	1.077
CARGO HANDLING	1.141	.457	.229	.152	.114	.091	.076	.393
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.213	.213	.213	.213	.213	.213	.213	.213
FREIGHT COMMISSIONS AND ADVERTISING	.003	.003	.003	.003	.003	.003	.003	.003
GENERAL AND ADMINISTRATIVE EXPENSES	.522	.256	.166	.137	.122	.113	.107	.231
TOTAL IOC	7.803	3.499	2.056	1.582	1.344	1.199	1.103	3.098

TABLE 31

DC-10-10 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 870 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	2000	3000	AVG. STAGE LENGTH
SYSTEM EXPENSE	.144	.066	.040	.031	.027	.020	.018	.029
LOCAL EXPENSE	2.282	.913	.456	.304	.228	.114	.076	.262
AIRCRAFT CONTROL	.070	.028	.014	.009	.007	.004	.002	.008
CABIN ATTENDANT	.400	.239	.185	.169	.161	.147	.143	.164
FOOD AND BEVERAGE	.397	.237	.184	.168	.159	.146	.142	.163
PASSENGER HANDLING	3.150	1.260	.630	.420	.315	.158	.105	.362
CARGO HANDLING	1.480	.592	.296	.198	.148	.074	.049	.170
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.215	.215	.215	.215	.215	.215	.215	.215
FREIGHT COMMISSIONS AND ADVERTISING	.006	.006	.006	.006	.006	.006	.006	.006
GENERAL AND ADMINISTRATIVE EXPENSES	.566	.259	.157	.124	.108	.082	.075	.115
TOTAL IOC	8.710	3.815	2.183	1.644	1.374	.966	.831	1.494

TABLE 32

DC-10-40 BASELINE - IOC COMPONENTS VS. DISTANCE (¢/AVAILABLE SEAT NM)
AVERAGE STAGE LENGTH - 670 NAUTICAL MILES

IOC COMPONENTS \ BLOCK DISTANCE (NM)	100	250	500	750	1000	2000	3000	AVG. STAGE LENGTH
SYSTEM EXPENSE	.171	.078	.047	.037	.032	.024	.021	.039
LOCAL EXPENSE	3.238	1.295	.648	.432	.324	.162	.108	.483
AIRCRAFT CONTROL	.077	.031	.015	.010	.008	.004	.003	.012
CABIN ATTENDANT	.440	.263	.203	.186	.177	.162	.157	.190
FOOD AND BEVERAGE	.396	.236	.183	.167	.159	.146	.141	.170
PASSENGER HANDLING	3.140	1.256	.628	.419	.314	.157	.105	.469
CARGO HANDLING	1.548	.619	.310	.206	.155	.077	.051	.231
OTHER PASSENGER SERVICE, COMMISSIONS AND ADVERTISING	.214	.214	.214	.214	.214	.214	.214	.214
FREIGHT COMMISSIONS AND ADVERTISING	.006	.006	.006	.006	.006	.006	.006	.006
GENERAL AND ADMINISTRATIVE EXPENSES	.655	.299	.181	.142	.122	.094	.085	.151
TOTAL IOC	9.885	4.297	2.435	1.819	1.431	1.046	.891	1.965

TABLE 33

BASELINE AND DERIVATIVE AIRCRAFT INDIRECT OPERATING COSTS - 1973 $
(Cents Per Available Seat Nautical Mile)

Aircraft Type	Seating Capacity	Stage Length (Nautical Miles)			
		500	1,000	1,500	3,000
DC-8-20	146	2.31	1.46	-	.90
DC-8-50	146	2.35	1.49	-	.91
DC-8-61	203	2.12	1.35	-	.84
DC-9-10	70	2.16	1.39	1.14	-
DC-9-30	92	2.06	1.34	1.10	-
DC-9-30D1	117	2.01	1.32	1.09	-
DC-9-30D2	122	1.99	1.31	1.08	-
DC-9-30D3	92	2.06	1.34	1.11	-
DC-10-10	277	2.18	1.37	-	.83
DC-10-10D	199	2.23	1.41	-	.86
DC-10-40	252	2.44	1.51	-	.89
DC-10-40D	327	2.19	1.38	-	.84

at a 58 percent load factor since IOC's do vary directly and significantly with traffic density. Obviously, in terms of cents per available seat nautical mile, a similar airplane type with a higher seating capacity should have lower IOC's. However, the IOC's of the DC-10-10D increase slightly over those for the baseline DC-10-10. This is due to the decrease in passenger capacity of the DC-10-10D at a 58 percent load factor of 45 passengers relative to the DC-10-10. On the other hand, IOC's for the DC-10-40D are significantly less than the baseline DC-10-40 due to the addition of 44 passengers at a 58 percent load factor.

All New 1980 Airplanes - The IOC's for the twelve N80 aircraft at various stage lengths are shown in Table 34. Since the four airplanes within each family have the same seating capacity, no large variation in IOC's were expected between the various models. However, the block times for each airplane within a family is different with the aircraft optimized for minimum fuel consumption being the slowest. As shown in Table 34, it is only the IOC's of the minimum fuel designs that vary significantly from those of the airplanes optimized for minimum DOC's. This was due primarily to the significant increases in block times for the minimum fuel aircraft.

2.5.5 Relationship of IOC to DOC

Indirect operating cost curves for the baseline aircraft are shown in Figures 38-44. Also plotted on these curves are the DOC's for these airplanes calculated at a pre-energy crisis fuel price of 15 cents per gallon. As can be seen from the curves as well as in Table 35, the relationship of IOC to DOC varies substantially with stage length. This is due to the very high indirect operating costs experienced on the shorter stage lengths.

Table 36 illustrates what happens to this relationship when the DOC's are calculated at the three NASA-specified fuel prices. Since IOC's were calculated for DOC's based on a fuel price of 15 cents per gallon and not varied with fuel price, they become a lesser percentage of DOC as fuel price increases.

TABLE 34

N80 AIRCRAFT INDIRECT OPERATING COSTS - 1973 $
(Cents Per Available Seat Nautical Mile)

Aircraft Type	Seating Capacity	Block Time (At 1,000 NM) (Hr)	Stage Length (Nautical Miles)			
			500	1,000	1,500	3,000
N80 - 2.15_{15}	201	2.40	2.07	1.32	1.07	-
N80 - 2.15_{30}	201	2.48	2.07	1.33	1.08	-
N80 - 2.15_{60}	201	2.55	2.08	1.34	1.09	-
N80 - 2.15_{MF}	201	2.77	2.12	1.38	1.13	-
N80 - 2.30_{15}	201	2.41	2.17	1.37	-	.84
N80 - 2.30_{30}	201	2.47	2.17	1.38	-	.85
N80 - 2.30_{60}	201	2.56	2.16	1.39	-	.87
N80 - 2.30_{MF}	201	2.78	2.20	1.43	-	.91
N80 - 4.30_{15}	404	2.42	2.05	1.30	-	.80
N80 - 4.30_{30}	404	2.50	2.06	1.31	-	.81
N80 - 4.30_{60}	404	2.57	2.07	1.32	-	.81
N80 - 4.30_{MF}	404	2.80	2.12	1.37	-	.86

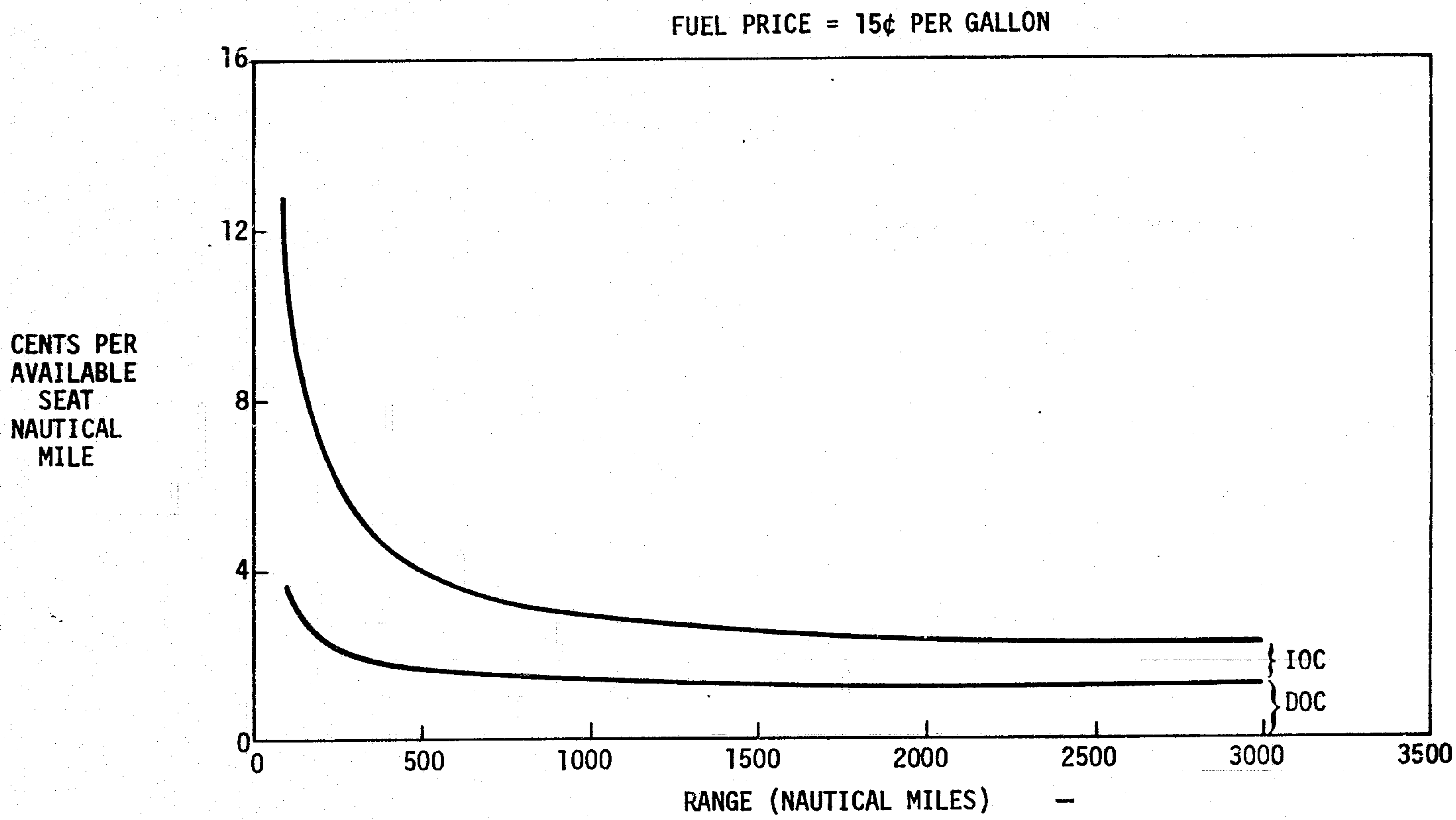


Figure 38. DC-8-20 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

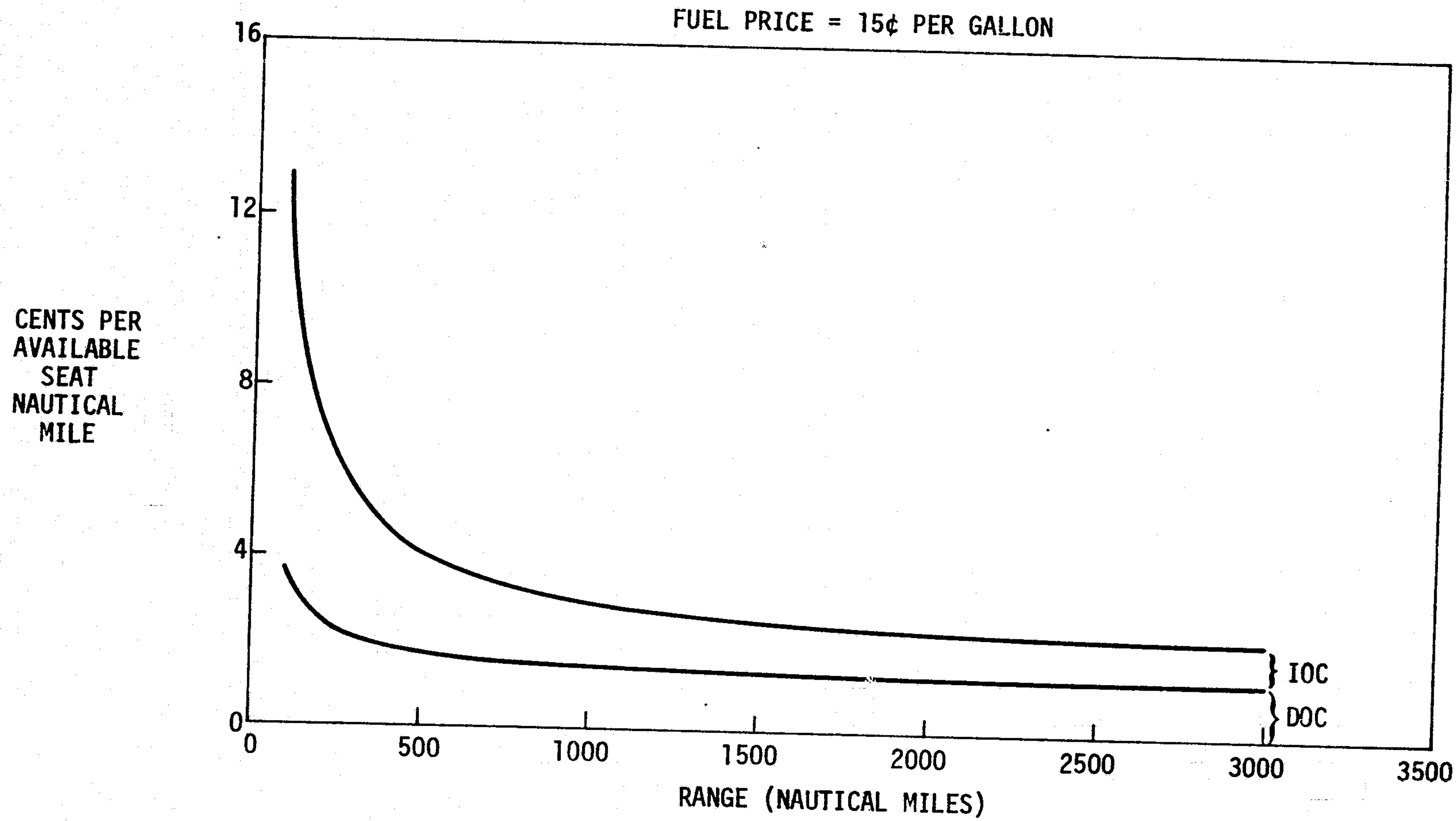


Figure 39. DC-8-50 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

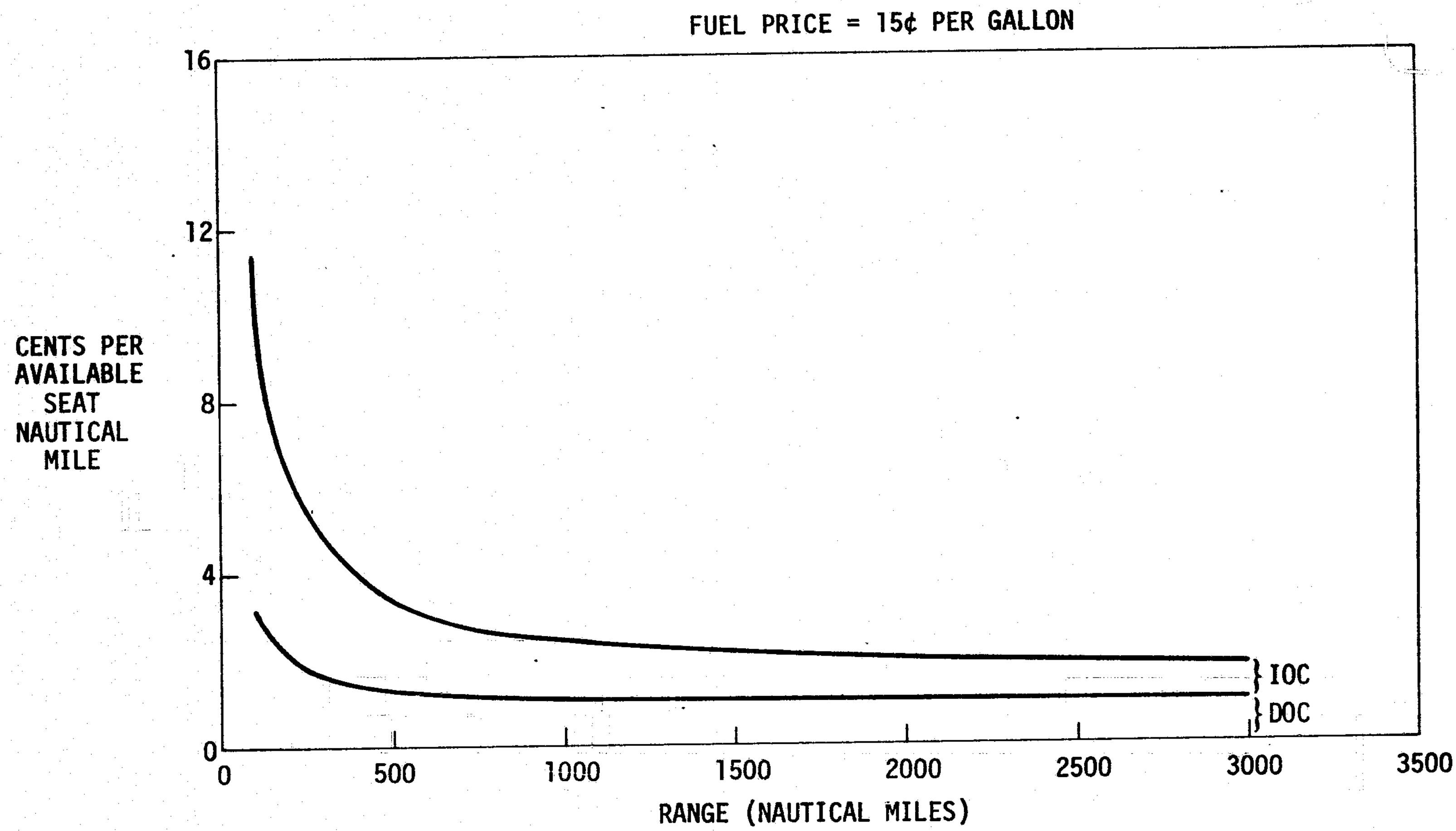


Figure 40. DC-8-61 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

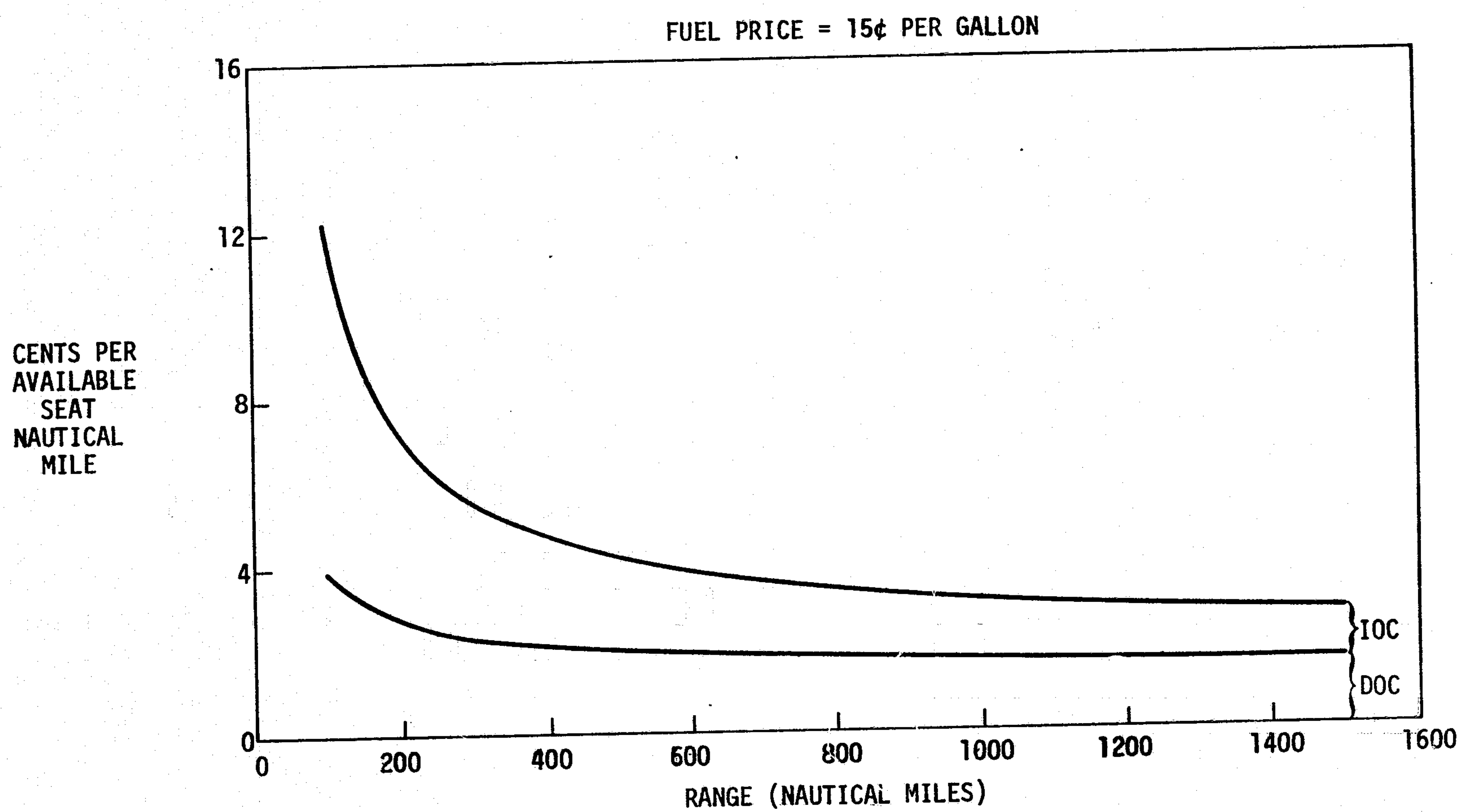


Figure 41. DC-9-10 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

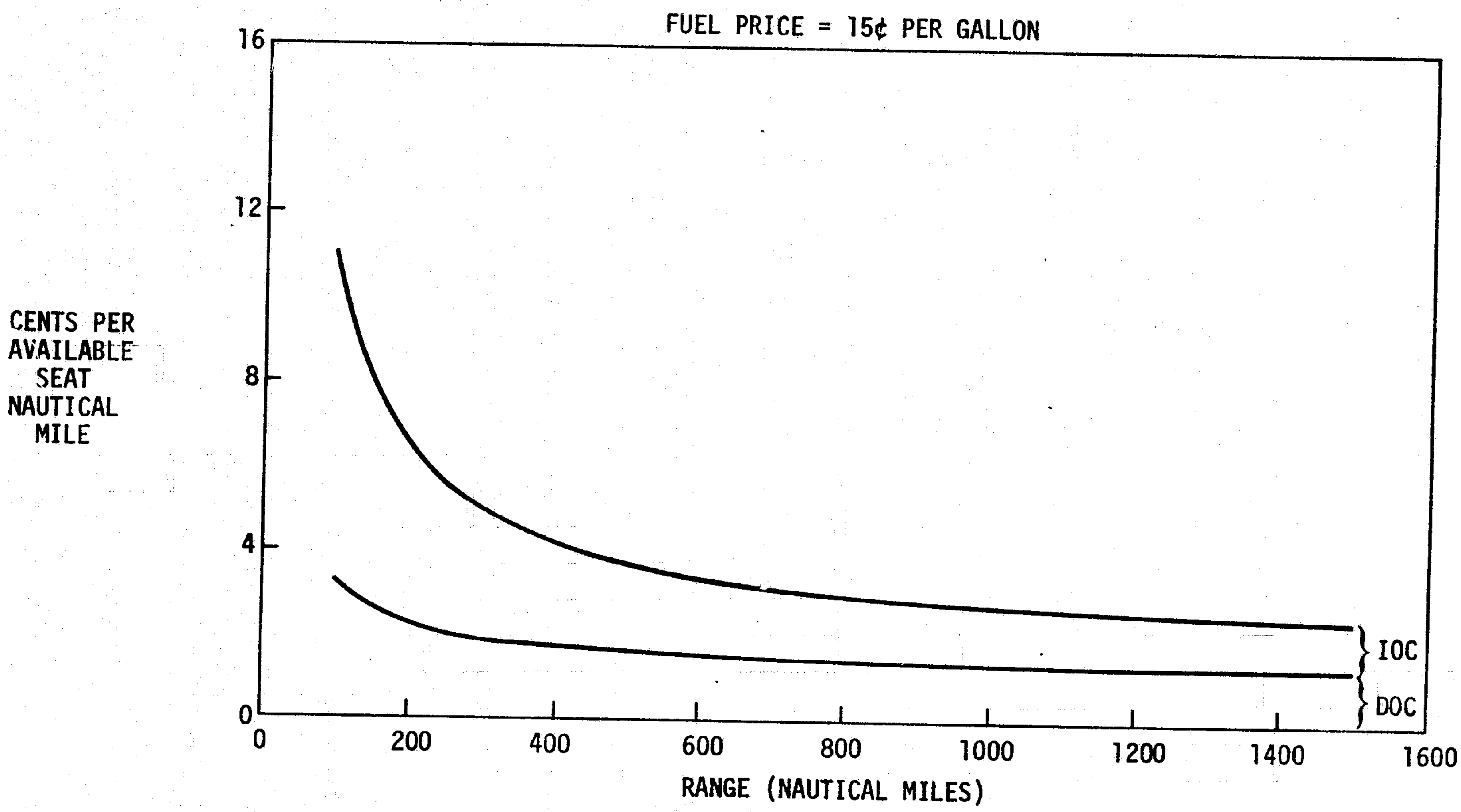


Figure 42. DC-9-30 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

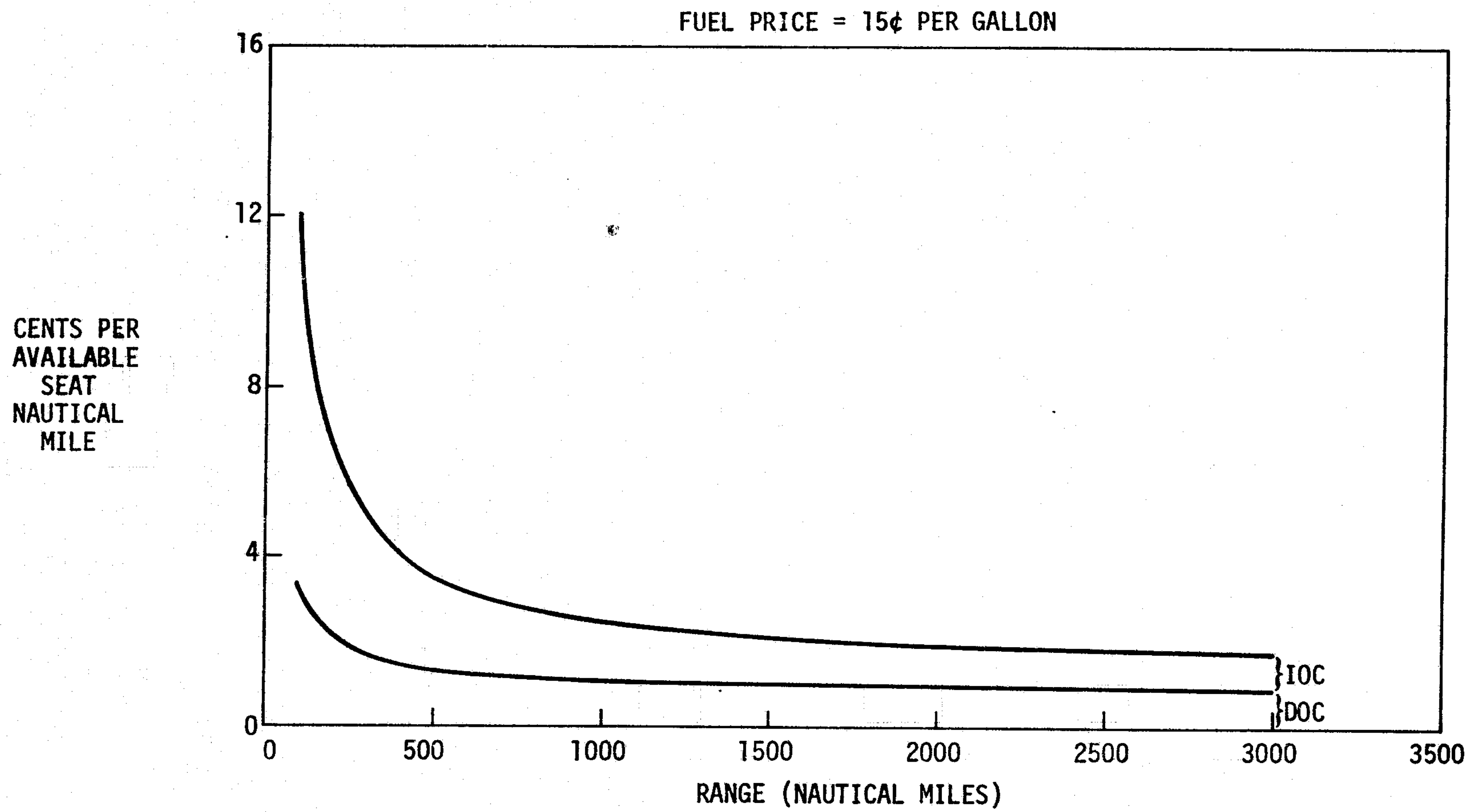


Figure 43. DC-10-10 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

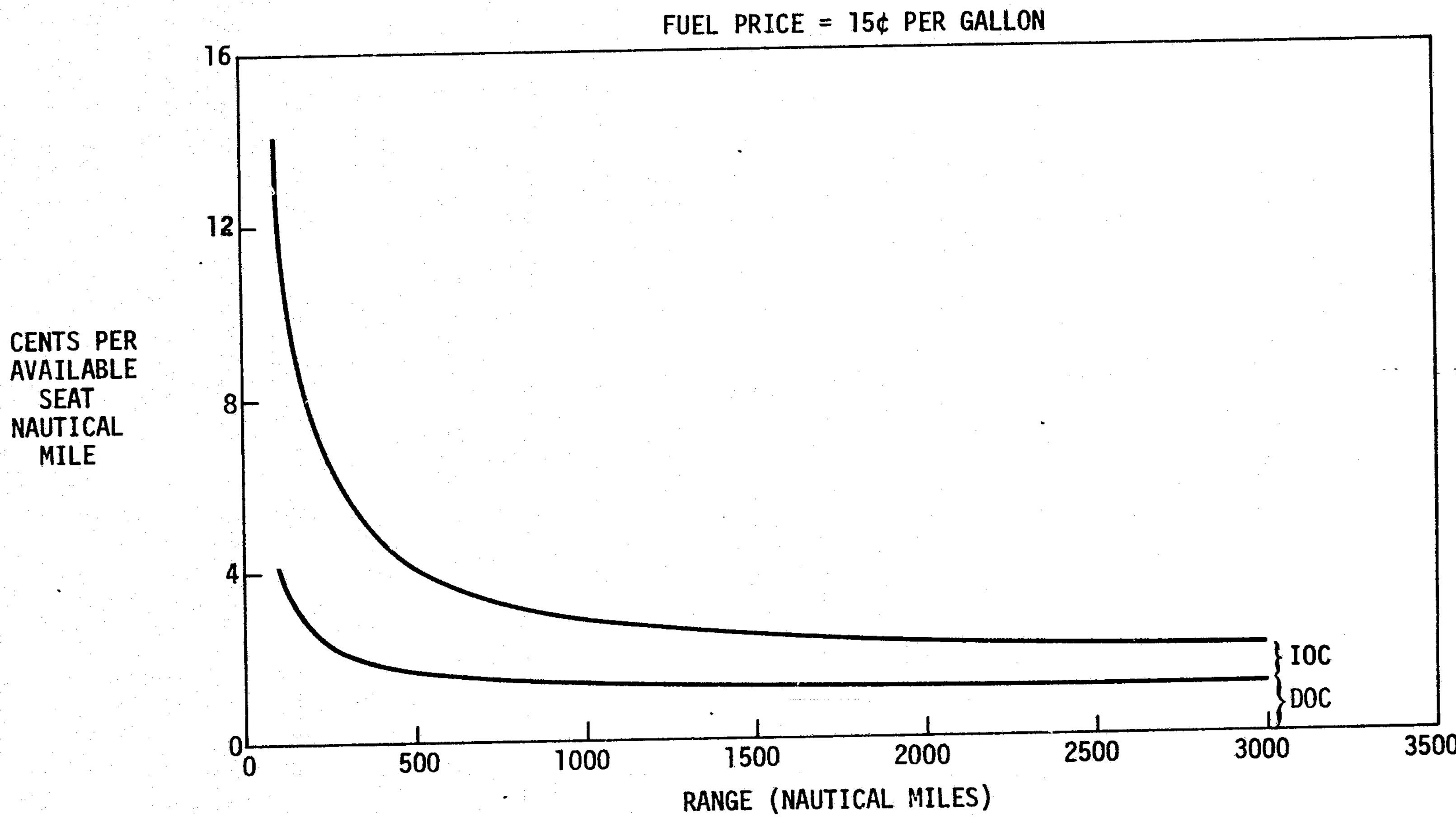


Figure 44. DC-10-40 BASELINE - DIRECT AND INDIRECT OPERATING COSTS VS. RANGE

TABLE 35

INDIRECT OPERATING COSTS AS A PERCENTAGE OF DIRECT OPERATING COSTS

DOC Fuel Price = 15¢ Per Gallon

STAGE LENGTH (NM)	DC-8-61	DC-9-30	DC-10-10	DC-10-40
100	261	240	262	237
250	206	173	210	189
500	159	130	165	149
750	135	108	140	126
1,000	120	96	126	113
1,500	-	83	-	-
2,000	94	-	100	88
3,000	84	-	88	77

TABLE 36

IOC AS A PERCENTAGE OF DOC AT THREE FUEL PRICES

Average Stage Length (NM)	DC-9-30 290	DC-10-40 670	DC-8-61 800	DC-10-10 870
Fuel Price (¢ Per Gal):				
15¢	163	132	132	133
30¢	134	106	103	107
60¢	99	77	72	76

2.7 Total Operating Costs

As shown in Section 2.6.5, the impact of IOC's on total operating costs is reduced as the price of fuel increases causing DOC's to rise rapidly. Therefore, the addition of the indirect operating costs to the direct operating costs did not alter the economic selection of the aircraft options.

Each of the baseline airplanes and aircraft options were offered to the market using the fleet forecasting model in Phase II. Since an economic selection of one aircraft type over another was not always possible due to differing seating capacities as well as design ranges, the airplanes were selected by the model on its ability to best serve each market as well as maximize system profit. Economic tradeoffs between aircraft in the fleet forecasting model were made on the basis of total operating costs.

Total operating costs for the seven baseline aircraft are plotted for the three fuel prices in Figures 45-51. As indicated on the curves, the impact on TOC's of a fuel price at 60 cents per gallon is very significant, especially in maintaining profitable airline operations.

Comparative Total Operating Costs - The TOC's for the retrofit, modification and derivative aircraft options were compared to those of the baseline aircraft at fuel prices of 30 cents and 60 cents per gallon. Results of these comparisons in terms of cents per available seat nautical mile at the 1973 CAB average stage length are shown in Figures 52 and 53. As fuel price increases from 30 cents (Figure 52) to 60 cents per gallon (Figure 53), more aircraft options become economically attractive than with 30 cent fuel.

Tables 37-51 document the total operating costs at various stage lengths for each baseline airplane as well as the 32 aircraft options. These are given at the three fuel prices in terms of cents per available seat nautical mile.

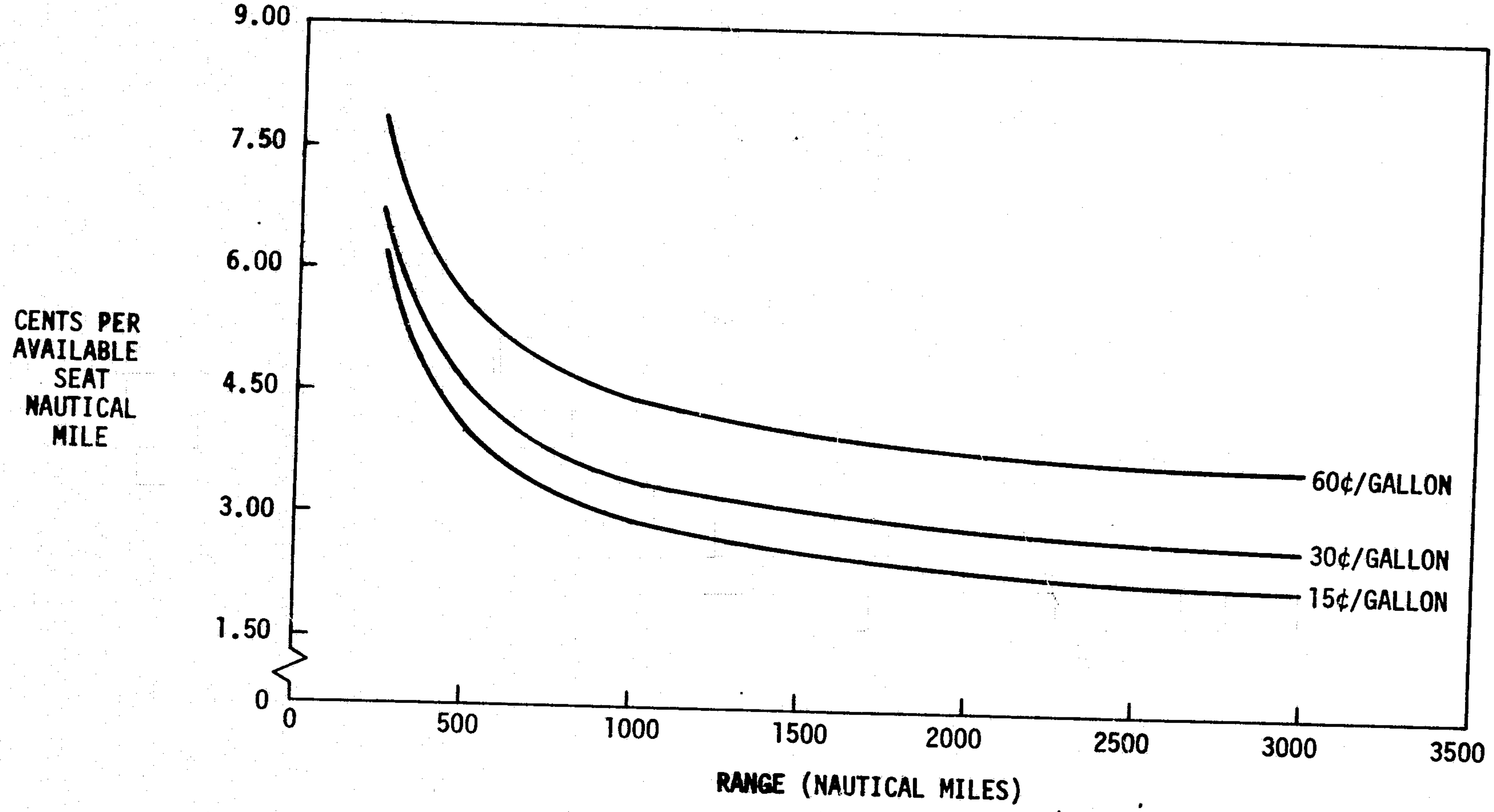


Figure 45. DC-8-20 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

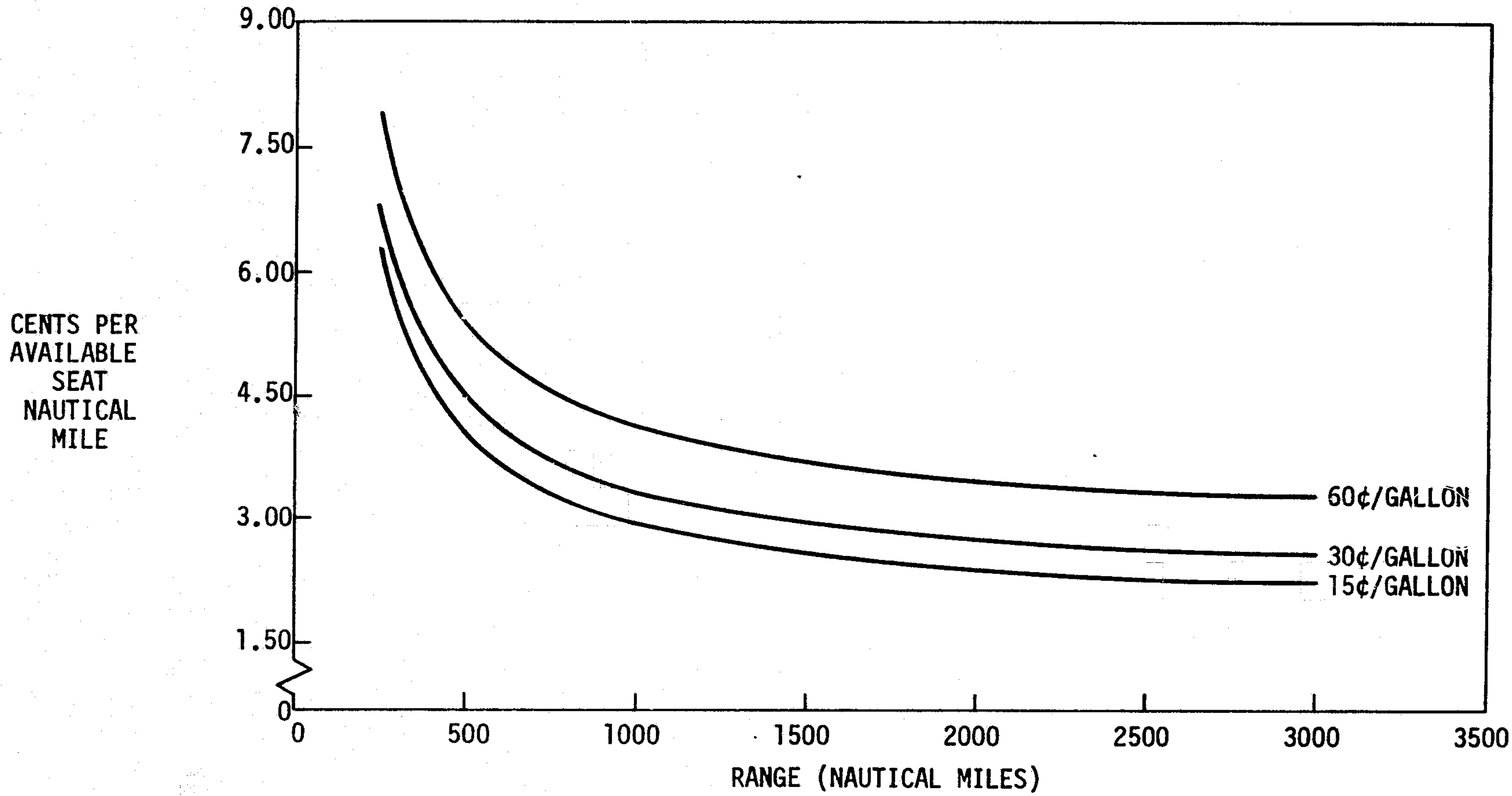


Figure 46. DC-8-50 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

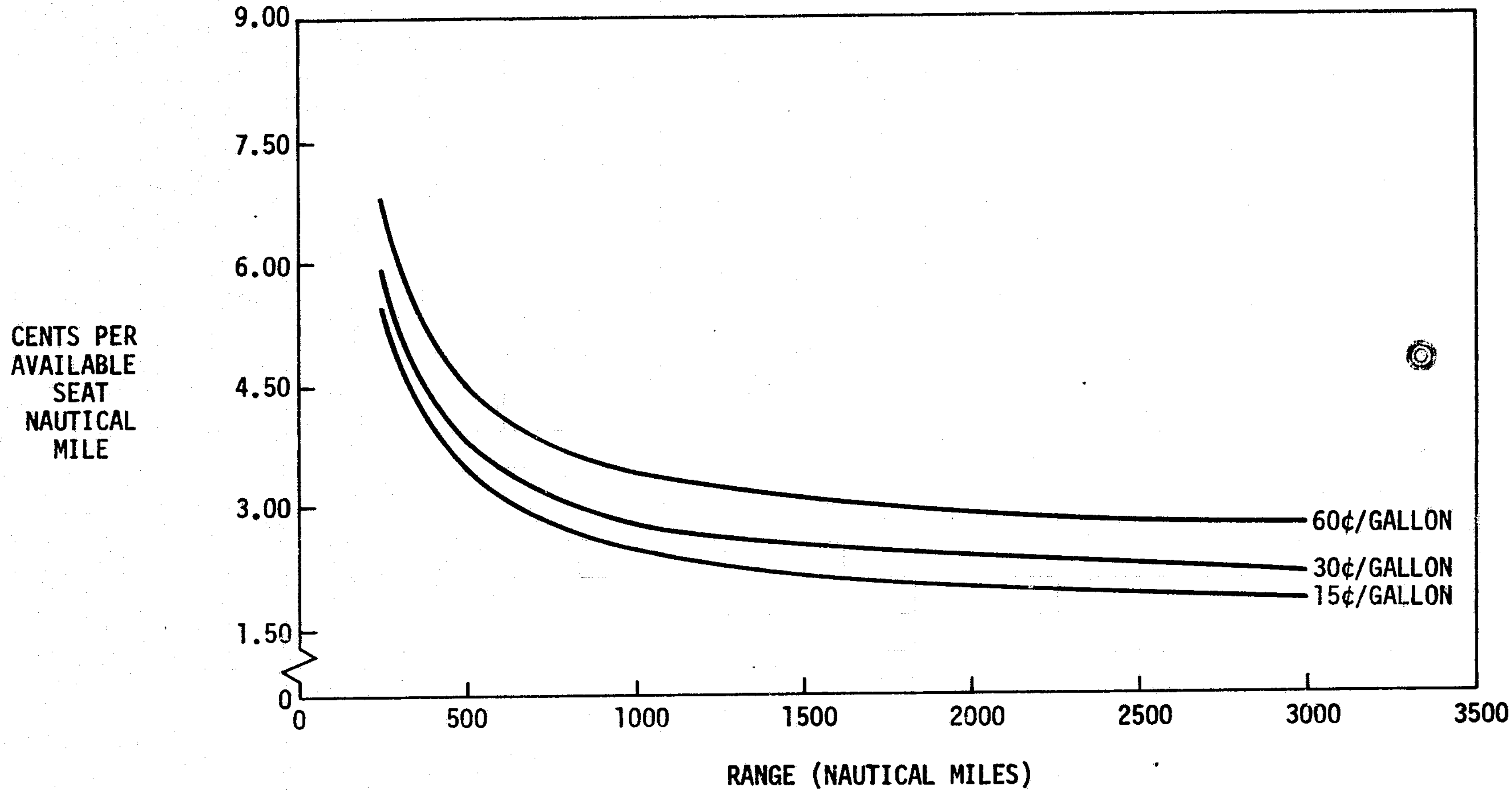


Figure 47. DC-8-61 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

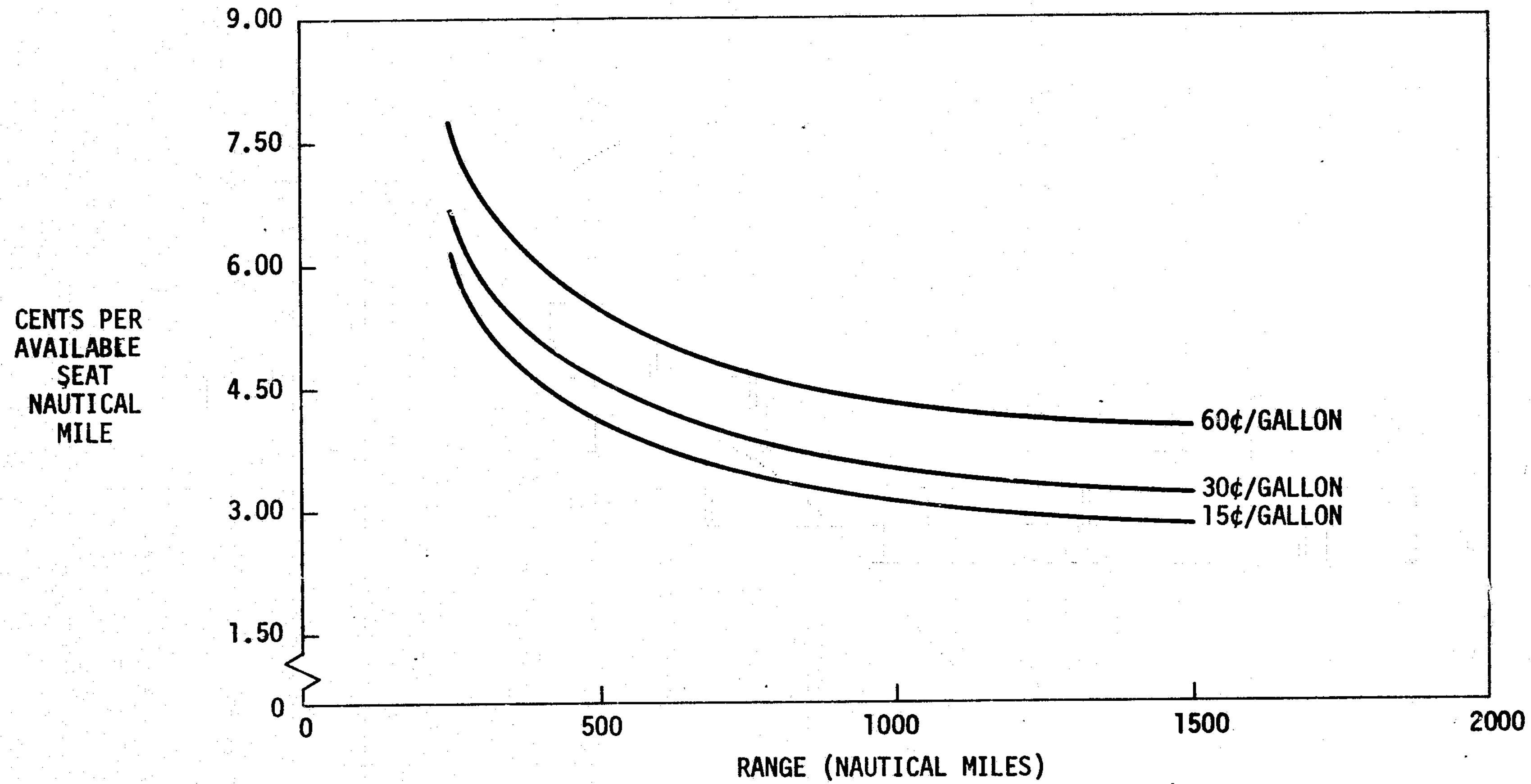


Figure 48. DC-9-10 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

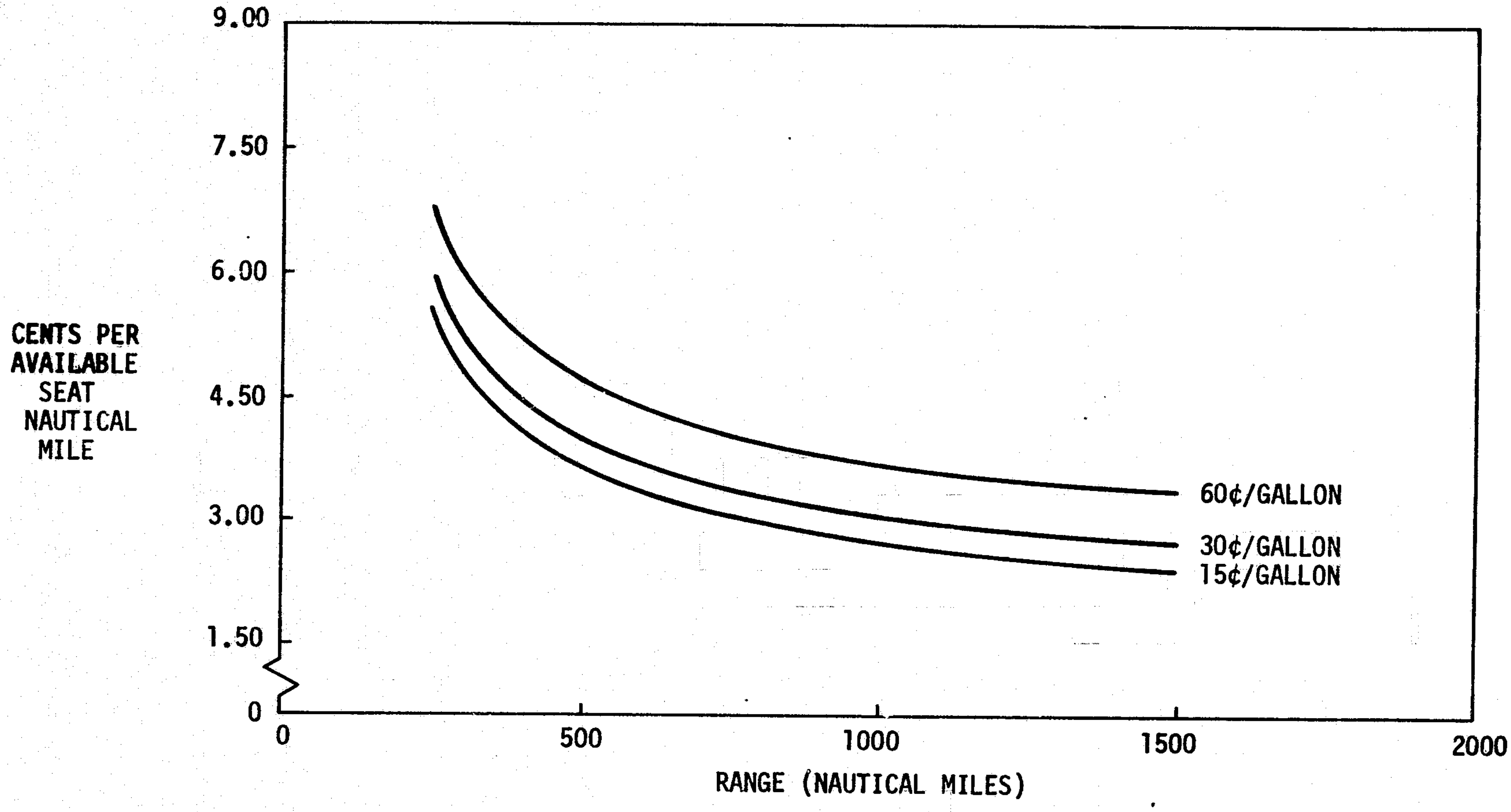


Figure 49. DC-9-30 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

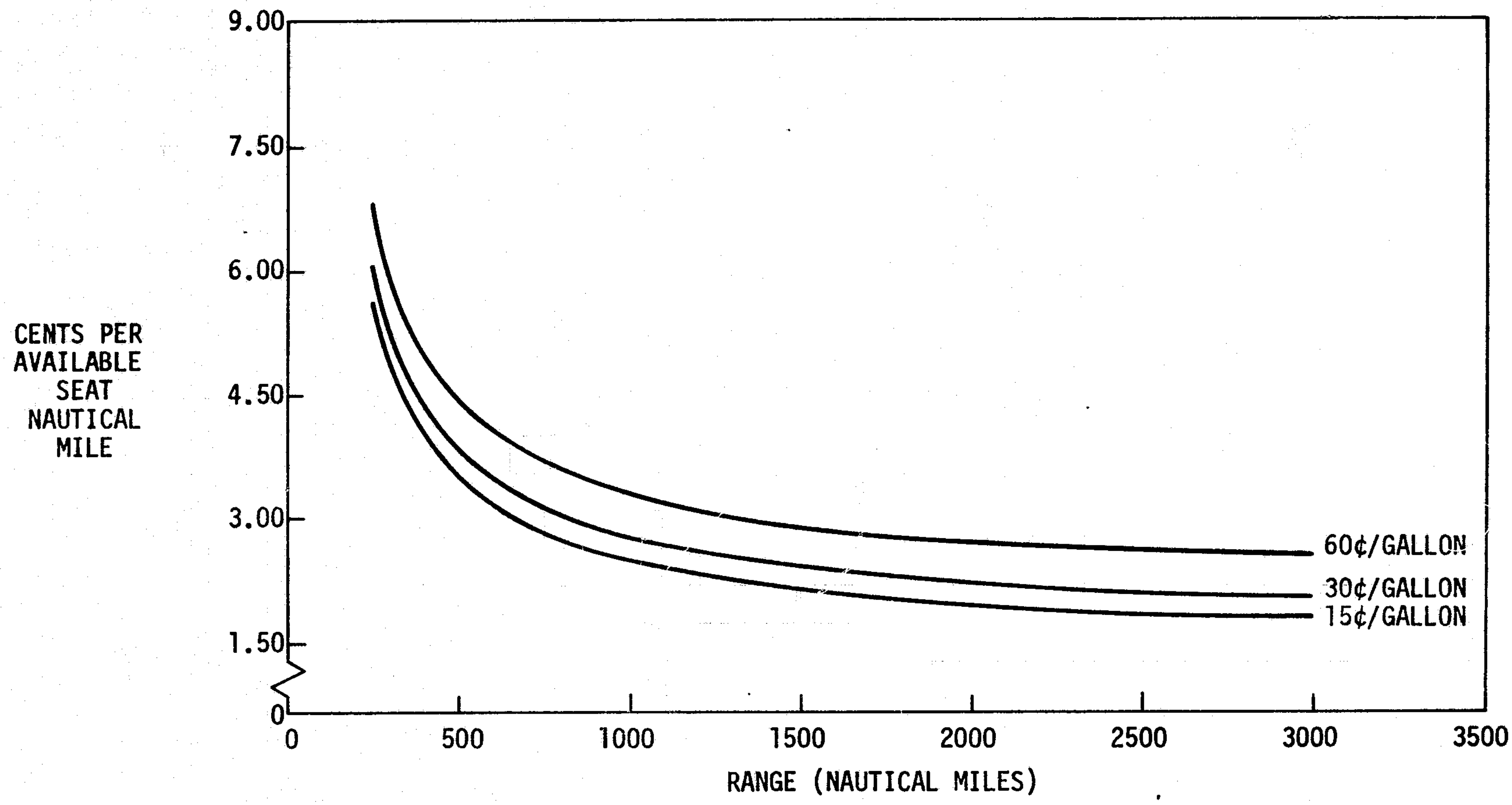


Figure 50. DC-10-10 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

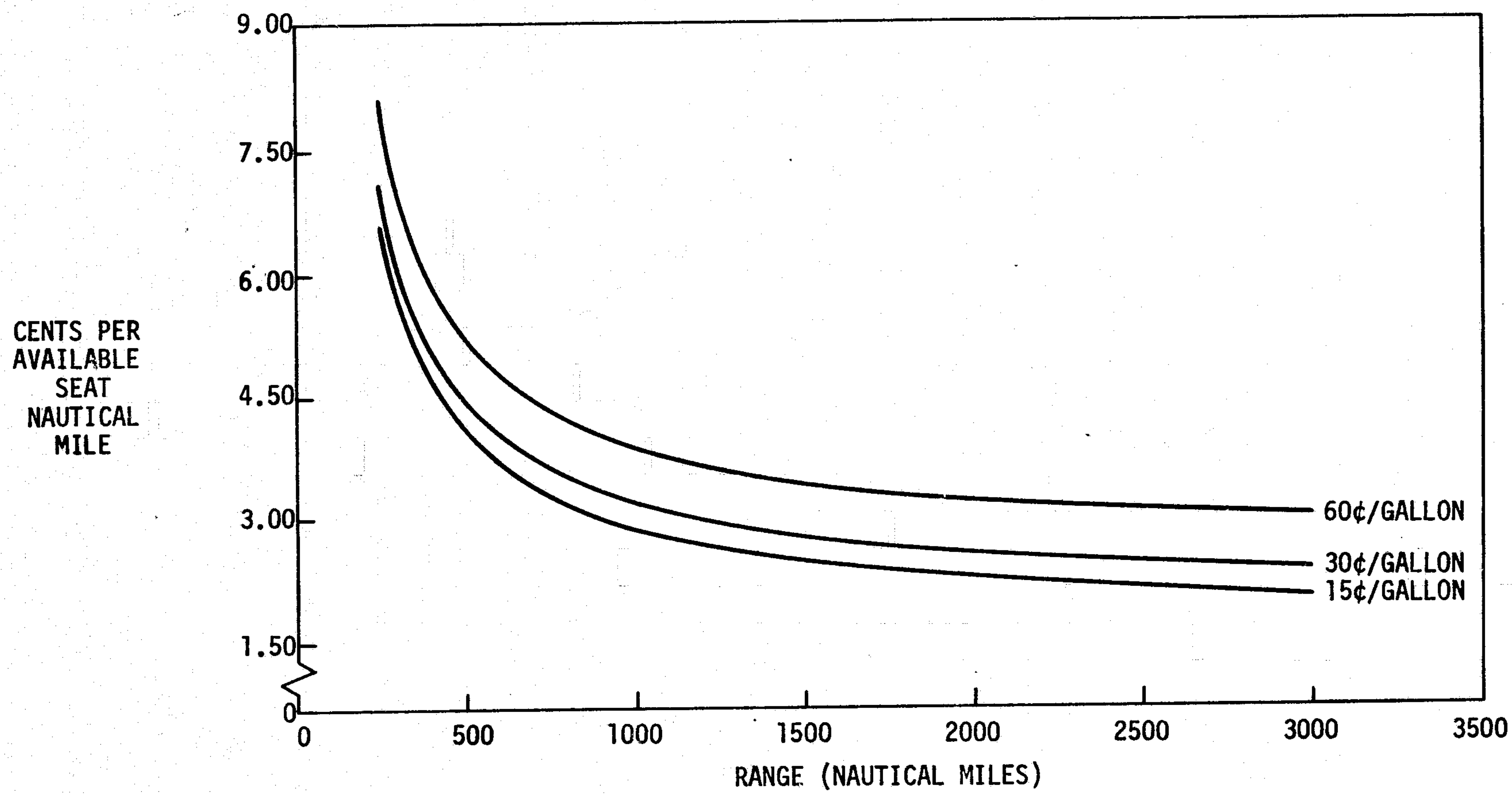


Figure 51. DC-10-40 BASELINE - TOTAL OPERATING COSTS VS. RANGE AT THREE FUEL PRICES

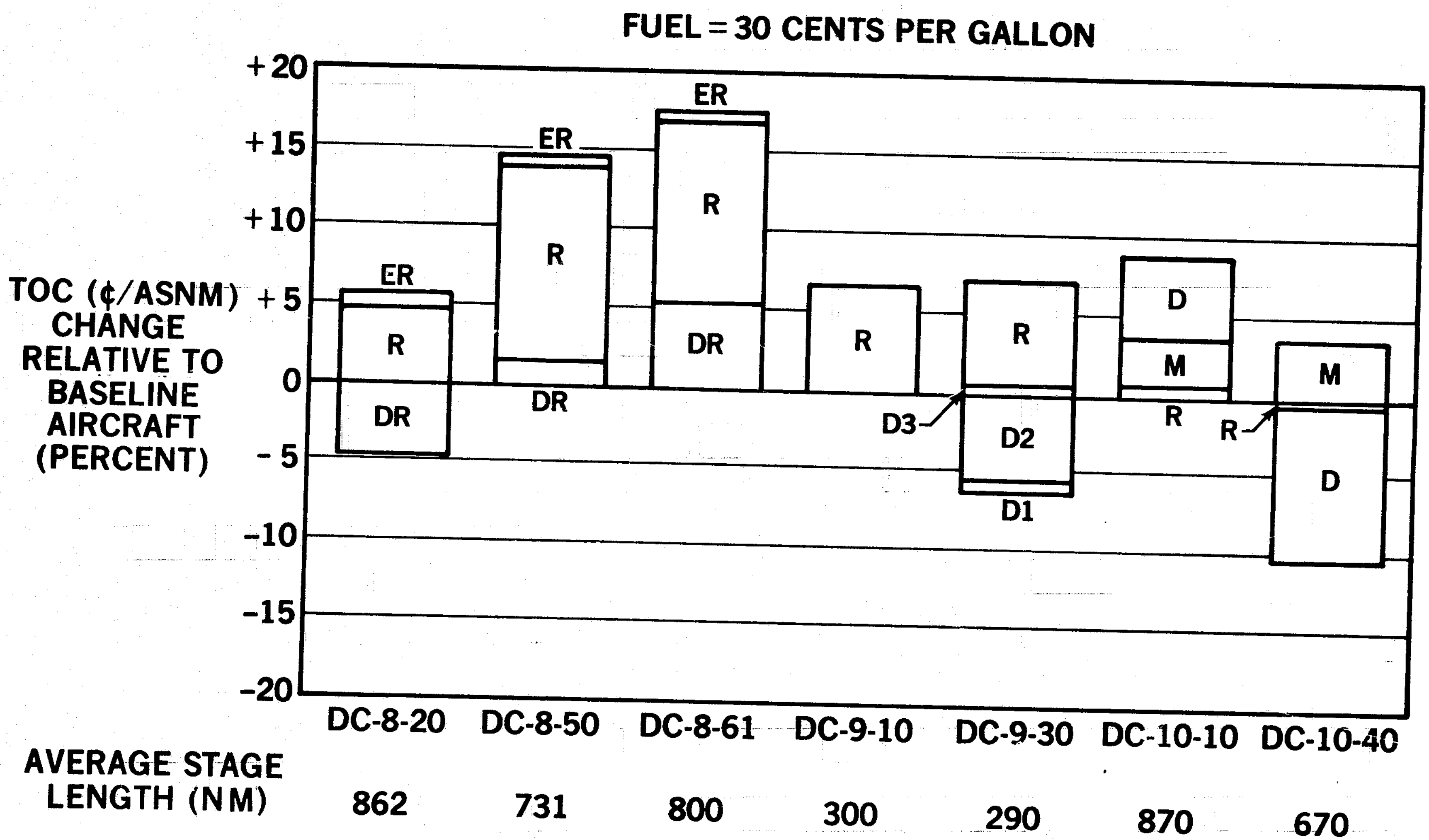


FIGURE 52. RETROFITS, MODIFICATIONS AND DERIVATIVES - TOC CHANGE (PERCENT)

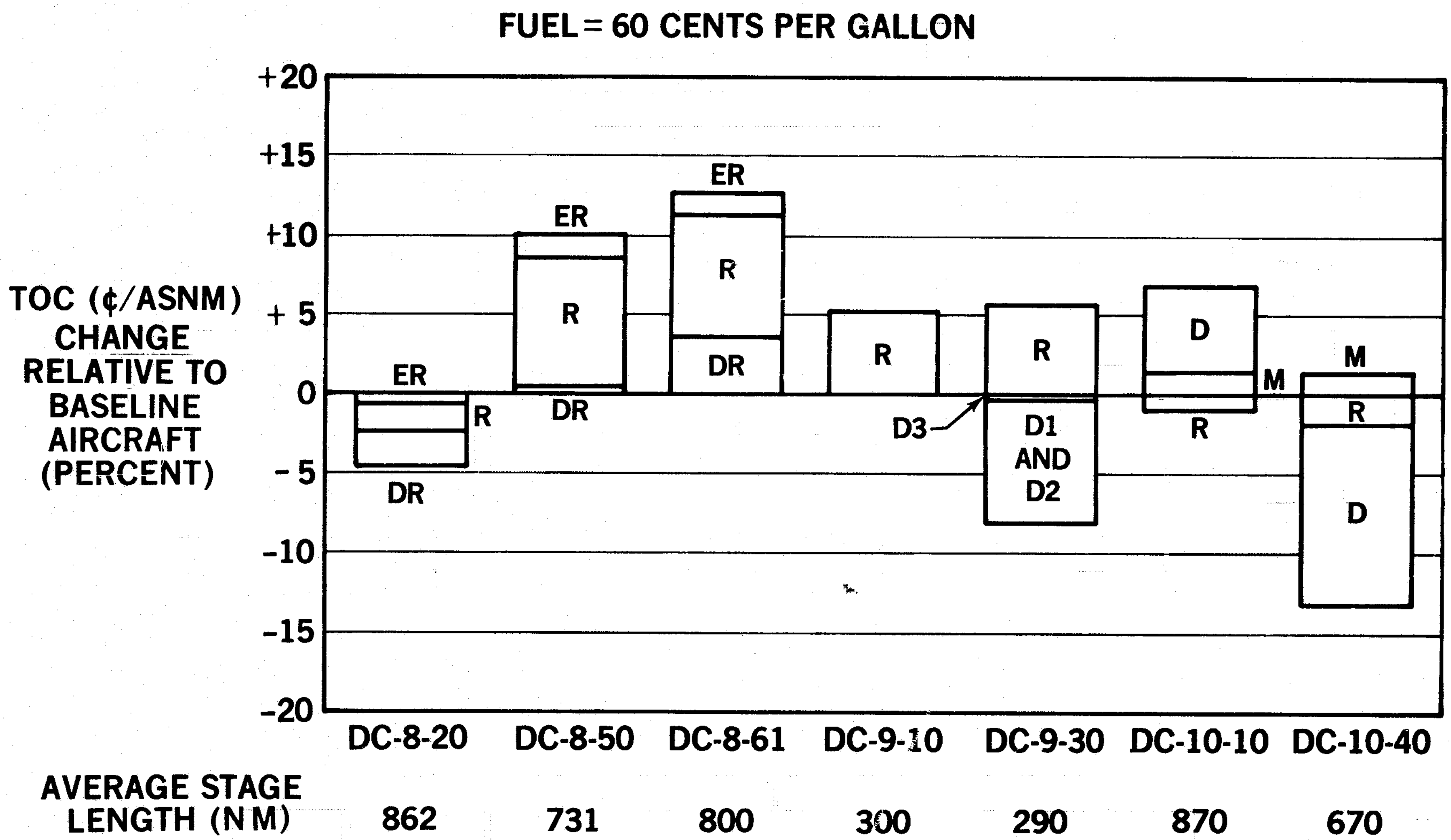


FIGURE 53. RETROFITS, MODIFICATIONS AND DERIVATIVES - TOC CHANGE (PERCENT)

TABLE 37

BASELINE AIRCRAFT - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 15¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-8-20	DC-8-50	DC-8-61	DC-9-10	DC-9-30	DC-10-10	DC-10-40
100	12.79	12.94	11.55	12.16	11.05	12.04	14.06
250	6.18	6.29	5.47	6.13	5.52	5.64	6.57
500	4.04	4.06	3.45	4.15	3.65	3.50	4.08
750	3.31	3.32	2.80	3.48	3.04	2.81	3.26
1,000	2.95	2.95	2.47	3.13	2.73	2.46	2.85
1,250	--	--	--	2.94	2.55	--	--
1,500	--	--	--	2.82	2.42	--	--
2,000	2.41	2.39	2.00	--	--	1.94	2.25
3,000	2.23	2.20	1.84	--	--	1.77	2.05
AVG. STAGE	3.13	3.36	2.72	5.47	5.00	2.61	3.46

TABLE 38

BASELINE AIRCRAFT - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 30¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-8-20	DC-8-50	DC-8-61	DC-9-10	DC-9-30	DC-10-10	DC-10-40
100	13.65	13.74	12.29	12.93	11.66	12.71	14.93
250	6.74	6.83	5.93	6.67	5.95	6.04	7.08
500	4.56	4.50	3.80	4.60	4.01	3.81	4.46
750	3.81	3.73	3.13	3.89	3.37	3.10	3.62
1,000	3.45	3.34	2.79	3.53	3.05	2.73	3.19
1,250	--	--	--	3.34	2.86	--	--
1,500	--	--	--	3.22	2.74	--	--
2,000	2.90	2.76	2.30	--	--	2.21	2.57
3,000	2.72	2.56	2.15	--	--	2.04	2.37
AVG. STAGE	3.63	3.77	3.05	5.97	5.41	2.89	3.82

TABLE 39

BASELINE AIRCRAFT - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 60¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-8-20	DC-8-50	DC-8-61	DC-9-10	DC-9-30	DC-10-10	DC-10-40
100	15.37	15.33	13.77	14.47	12.88	14.06	16.69
250	7.87	7.92	6.83	7.75	6.81	6.84	8.10
500	5.60	5.40	4.51	5.50	4.72	4.43	5.24
750	4.83	4.56	3.77	4.72	4.04	3.67	4.33
1,000	4.45	4.14	3.41	4.33	3.69	3.28	3.86
1,250	--	--	--	4.15	3.50	--	--
1,500	--	--	--	4.03	3.37	--	--
2,000	3.88	3.50	2.91	--	--	2.73	3.20
3,000	3.69	3.29	2.77	--	--	2.56	3.01
AVG. STAGE	4.63	4.60	3.69	6.98	6.23	3.45	4.54

TABLE 40

BASELINE RETROFITS - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 15¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-8-20R	DC-8-50R	DC-8-61R	DC-9-10R	DC-9-30R	DC-10-10R	DC-10-40R
100	13.81	14.29	12.86	12.86	11.71	12.14	14.12
250	6.77	7.09	6.26	6.57	5.95	5.71	6.60
500	4.43	4.70	4.07	4.52	3.99	3.55	4.09
750	3.64	3.90	3.37	3.81	3.35	2.85	3.27
1,000	3.24	3.50	3.01	3.44	3.03	2.50	2.86
1,250	--	--	--	3.25	2.84	--	--
1,500	--	--	--	3.11	2.71	--	--
2,000	2.66	2.90	2.50	--	--	1.97	2.25
3,000	2.46	2.70	2.32	--	--	1.80	2.04
AVG. STAGE	3.44	3.94	3.28	5.88	5.40	2.65	3.47

TABLE 41

BASELINE RETROFITS - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 30¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-8-20R	DC-8-50R	DC-8-61R	DC-9-10R	DC-9-30R	DC-10-10R	DC-10-40R
100	14.62	15.08	13.50	13.60	12.30	12.76	14.95
250	7.27	7.58	6.65	7.09	6.36	6.08	7.07
500	4.84	5.08	4.37	4.94	4.33	3.84	4.45
750	4.01	4.25	3.65	4.20	3.67	3.11	3.59
1,000	3.60	3.84	3.28	3.82	3.33	2.75	3.16
1,250	--	--	--	3.63	3.14	--	--
1,500	--	--	--	3.49	3.00	--	--
2,000	2.99	3.21	2.75	--	--	2.21	2.52
3,000	2.78	3.00	2.58	--	--	2.03	2.32
AVG. STAGE	3.80	4.30	3.56	6.37	5.79	2.91	3.80

TABLE 42

BASELINE RETROFITS - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 60¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-8-20R	DC-8-50R	DC-8-61R	DC-9-10R	DC-9-30R	DC-10-10R	DC-10-40R
100	16.23	16.66	14.78	15.08	13.48	13.99	16.63
250	8.28	8.55	7.42	8.12	7.18	6.82	8.02
500	5.64	5.85	4.97	5.80	5.01	4.42	5.16
750	4.75	4.95	4.20	4.99	4.30	3.64	4.23
1,000	4.30	4.51	3.81	4.58	3.95	3.25	3.76
1,250	--	--	--	4.38	3.73	--	--
1,500	--	--	--	4.25	3.60	--	--
2,000	3.64	3.83	3.27	--	--	2.67	3.07
3,000	3.42	3.60	3.09	--	--	2.49	2.87
AVG. STAGE	4.52	5.00	4.10	7.33	6.58	3.42	4.45

TABLE 43

BASELINE RETROFITS - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 15¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)					
	DC-8-20DR	DC-8-20ER	DC-8-50DR	DC-8-50ER	DC-8-61DR	DC-8-61ER
100	12.49	13.78	13.12	14.26	11.95	12.87
250	5.98	6.76	6.39	7.09	5.71	6.27
500	3.87	4.44	4.14	4.70	3.64	4.07
750	3.15	3.64	3.39	3.90	2.98	3.38
1,000	2.80	3.25	3.01	3.51	2.64	3.02
1,250	--	--	--	--	--	--
1,500	--	--	--	--	--	--
2,000	2.27	2.67	2.45	2.91	2.15	2.51
3,000	2.09	2.48	2.26	2.70	1.99	2.33
AVG. STAGE	2.97	3.45	3.43	3.95	2.90	3.29

TABLE 44

BASELINE RETROFITS - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 30¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)					
	DC-8-20DR	DC-8-20ER	DC-8-50DR	DC-8-50ER	DC-8-61DR	DC-8-61ER
100	13.34	14.60	13.92	15.05	12.66	13.54
250	6.54	7.27	6.92	7.60	6.15	6.67
500	4.37	4.86	4.57	5.10	3.98	4.39
750	3.64	4.04	3.78	4.27	3.29	3.67
1,000	3.27	3.63	3.39	3.86	2.94	3.30
1,250	--	--	--	--	--	--
1,500	--	--	--	--	--	--
2,000	2.73	3.02	2.80	3.24	2.44	2.78
3,000	2.55	2.82	2.60	3.02	2.28	2.60
AVG. STAGE	3.45	3.83	3.82	4.32	3.20	3.58

TABLE 45

BASELINE RETROFITS - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 60¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)					
	DC-3-20DR	DC-8-20ER	DC-8-50DR	DC-8-50ER	DC-8-61DR	DC-8-61ER
100	15.04	16.23	15.51	16.64	14.08	14.88
250	7.65	8.30	7.98	8.61	7.01	7.48
500	5.38	5.70	5.42	5.91	4.65	5.02
750	4.60	4.82	4.37	5.01	3.90	4.25
1,000	4.22	4.38	4.15	4.57	3.53	3.86
1,250	--	--	--	--	--	--
1,500	--	--	--	--	--	--
2,000	3.65	3.73	3.51	3.89	3.02	3.32
3,000	3.47	3.51	3.29	3.66	2.87	3.14
AVG. STAGE	4.41	4.60	4.62	5.06	3.82	4.15

TABLE 46

MODIFICATIONS AND DERIVATIVES - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 15¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-10-10M	DC-10-10D	DC-10-40M	DC-10-40D	DC-9-30D1	DC-9-30D2	DC-9-30D3
100	12.42	12.49	14.58	12.47	10.47	10.54	11.18
250	5.85	5.92	6.84	5.86	5.22	5.28	5.58
500	3.66	3.76	4.27	3.70	3.48	3.52	3.68
750	2.94	3.08	3.42	2.99	2.90	2.93	3.06
1,000	2.58	2.68	3.00	2.62	2.61	2.64	2.75
1,250	--	--	--	--	2.44	2.46	2.56
1,500	--	--	--	--	2.32	2.34	2.43
2,000	2.05	2.15	2.37	2.07	--	--	--
3,000	1.87	1.98	2.16	1.90	--	--	--
AVG. STAGE	2.75	2.89	3.62	3.15	4.75	4.79	5.04

TABLE 47

MODIFICATIONS AND DERIVATIVES - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 30¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-10-10M	DC-10-10D	DC-10-40M	DC-10-40D	DC-9-30D1	DC-9-30D2	DC-9-30D3
100	13.04	13.22	15.41	13.04	10.98	11.01	11.76
250	6.22	6.34	7.31	6.22	5.57	5.61	5.99
500	3.94	4.07	4.62	3.98	3.77	3.79	4.01
750	3.20	3.36	3.74	3.24	3.17	3.19	3.38
1,000	2.83	2.95	3.30	2.87	2.87	2.88	3.05
1,250	--	--	--	--	2.70	2.70	2.85
1,500	--	--	--	--	2.58	2.58	2.72
2,000	2.28	2.41	2.64	2.30	--	--	--
3,000	2.10	2.24	2.43	2.13	--	--	--
AVG. STAGE	3.00	3.16	3.95	3.41	5.08	5.10	5.43

TABLE 48

MODIFICATIONS AND DERIVATIVES - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

FUEL = 60¢/GALLON

TRIP DISTANCE (NM)	TOC (¢ PER AVAILABLE SEAT NAUTICAL MILE)						
	DC-10-10M	DC-10-10D	DC-10-40M	DC-10-40D	DC-9-30D1	DC-9-30D2	DC-9-30D3
100	14.27	14.69	17.06	14.18	11.99	11.95	12.93
250	6.96	7.17	8.25	6.92	6.26	6.27	6.80
500	4.51	4.69	5.32	4.55	4.36	4.33	4.69
750	3.71	3.92	4.36	3.76	3.72	3.70	4.00
1,000	3.32	3.48	3.89	3.36	3.40	3.37	3.66
1,250	--	--	--	--	3.22	3.18	3.44
1,500	--	--	--	--	3.09	3.06	3.31
2,000	2.74	2.92	3.18	2.75	--	--	--
3,000	2.55	2.75	2.97	2.59	--	--	--
AVG. STAGE	3.51	3.70	4.59	3.93	5.73	5.72	6.21

TABLE 49

N80-2.15 - TOTAL OPERATING COSTS VS. DISTANCE ~ 1973 DOLLARS

(Cents Per Available Seat Nautical Mile)

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MINIMUM FUEL		
	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal
100	11.10	11.58	12.54	11.08	11.56	12.52	11.11	11.58	12.54	11.21	11.69	12.65
250	5.50	5.82	6.45	5.50	5.81	6.43	5.55	5.85	6.46	5.60	5.90	6.50
500	3.53	3.79	4.32	3.53	3.77	4.27	3.57	3.80	4.28	3.69	3.92	4.39
750	2.89	3.13	3.62	2.90	3.13	3.59	2.94	3.16	3.59	3.05	3.27	3.69
1,000	2.55	2.79	3.26	2.57	2.79	3.23	2.60	2.81	3.23	2.72	2.92	3.32
1,250	2.36	2.59	3.05	2.38	2.59	3.02	2.40	2.61	3.01	2.53	2.73	3.11
1,500	2.23	2.46	2.91	2.25	2.46	2.88	2.28	2.48	2.88	2.40	2.59	2.97

TABLE 50

N80-2.30 - TOTAL OPERATING COSTS VS. DISTANCE - 1973 DOLLARS

(Cents Per Available Seat Nautical Mile)

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MINIMUM FUEL		
	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal
100	12.54	13.13	14.31	12.53	13.12	14.30	12.51	13.10	14.28	12.60	13.19	14.37
250	5.98	6.34	7.05	5.98	6.33	7.05	5.99	6.35	7.06	6.04	6.40	7.11
500	3.81	4.09	4.66	3.81	4.08	4.62	3.80	4.07	4.60	3.93	4.19	4.72
750	3.08	3.34	3.87	3.09	3.34	3.84	3.13	3.37	3.85	3.27	3.50	3.97
1,000	2.72	2.97	3.47	2.75	2.98	3.46	2.79	3.01	3.46	2.93	3.15	3.59
1,500	2.38	2.62	3.10	2.40	2.63	3.09	2.44	2.66	3.09	2.58	2.79	3.20
2,000	2.19	2.43	2.91	2.22	2.44	2.89	2.27	2.48	2.90	2.41	2.61	3.02
2,500	2.10	2.34	2.81	2.13	2.35	2.80	2.17	2.38	2.80	2.31	2.51	2.91
3,000	2.03	2.28	2.75	2.06	2.28	2.74	2.11	2.32	2.74	2.25	2.45	2.85

TABLE 51

N80-4.30 - TOTAL OPERATING COSTS VS. DISTANCE ~ 1973 DOLLARS

(Cents Per Available Seat Nautical Mile)

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MINIMUM FUEL		
	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal	15¢/Gal	30¢/Gal	60¢/Gal
100	10.78	11.16	11.91	10.76	11.13	11.89	10.79	11.16	11.92	11.09	11.47	12.22
250	5.14	5.41	5.94	5.13	5.39	5.90	5.19	5.45	5.95	5.34	5.60	6.10
500	3.21	3.44	3.90	3.24	3.45	3.89	3.26	3.47	3.89	3.42	3.62	4.04
750	2.58	2.80	3.23	2.60	2.80	3.21	2.63	2.82	3.21	2.78	2.97	3.36
1,000	2.27	2.48	2.90	2.28	2.48	2.86	2.31	2.49	2.86	2.46	2.65	3.01
1,500	1.95	2.15	2.56	1.97	2.16	2.54	1.99	2.17	2.53	2.13	2.31	2.67
2,000	1.79	1.99	2.40	1.80	1.99	2.37	1.83	2.00	2.36	1.98	2.15	2.51
2,500	1.70	1.91	2.31	1.71	1.90	2.28	1.74	1.92	2.27	1.88	2.06	2.41
3,000	1.64	1.85	2.26	1.66	1.85	2.23	1.67	1.85	2.21	1.82	2.00	2.35

SECTION 3.0

PHASE II - U.S. DOMESTIC MARKET ANALYSIS

The objective in Phase II was to select the most promising modification, derivative or all-new aircraft options in terms of their fuel savings and economic viability, and then to project the U.S. aircraft market for the selected options. To accomplish this task, alternative fleet forecasts were developed to screen the aircraft options against the projected market requirements. The results of these fleet forecasts were then compared both economically and operationally. Criteria used in comparing viability included operating costs, potential airline profit, passenger demand satisfied, fuel saved, as well as the forecasted fleet size and mix.

3.1 Study Approach

Figure 54 outlines the approach taken in accomplishing the objectives of Phase II. Fuel conserving aircraft fleets were determined using the Performance Evaluation Technique (G8BD), an existing Douglas computer program. Inputs to the program included the passenger demand forecast developed in Phase I (Section 1.0), the baseline operational environment of the U.S. domestic airlines, the various alternative operating scenarios, as well as the different offerings of competitive aircraft options. The selected aircraft options were grouped into realistic combinations of aircraft offerings for each operational scenario. The 32 selected options competed not only among themselves, but also against the baseline existing aircraft.

The program selected from each offering of competitive options that fleet-mix which best satisfied the traffic demand and also met the evaluation criterion of maximizing airline profits. Operational conditions affecting the fleet-mix selection, including fuel availability and price, hub constraints, load factor variations, and aircraft operating procedures were considered by the program along with the alternative aircraft offerings.

A comparison of the changes in the detailed operational and economic statistics for each fleet forecast provided the information necessary to assess the operational and economic viability of the various aircraft options. This procedure was iterated to determine an optimal fleet-mix over the forecast

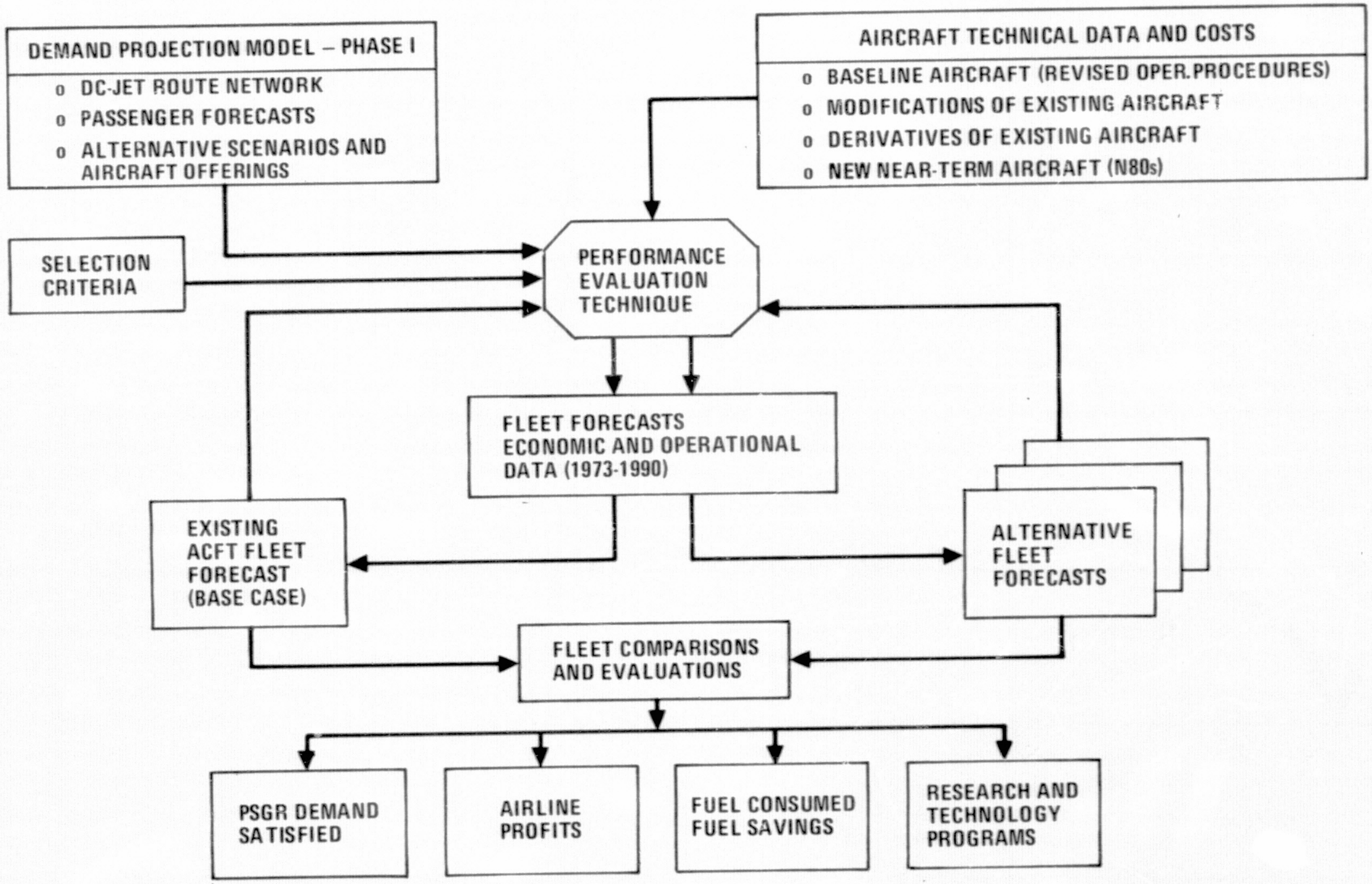


Figure 54. STUDY APPROACH - USE OF PERFORMANCE EVALUATION TECHNIQUE

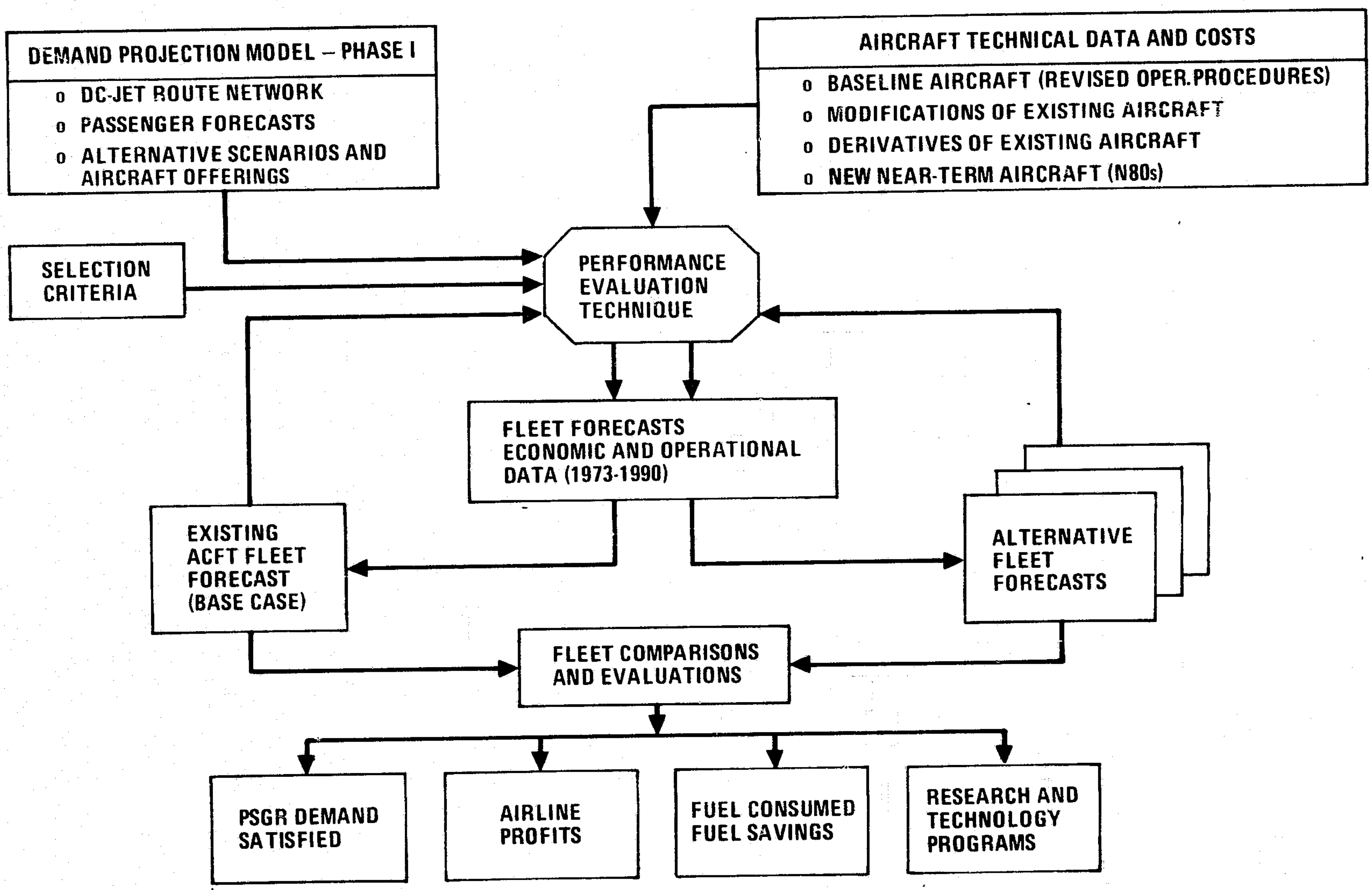


Figure 54. STUDY APPROACH - USE OF PERFORMANCE EVALUATION TECHNIQUE

period, 1973-1990, for each of the competitive aircraft offerings and its operational scenario. A typical printout of the results from the Performance Evaluation Technique for the year 1990 is shown in Section 1.9, Figure 10.

The fuel conserving forecasts were developed to represent the U.S. domestic air transportation system in both a restricted fuel as well as an unlimited fuel environment. The resulting fleets' fuel requirements were evaluated to define reasonable bounds around the potential jet-fuel demand through 1990.

The DC-Jet route network contained approximately 34 percent of the total U.S. domestic trunk and local service carriers' revenue passenger-miles. The spectrum of diverse equipment types serving this selected market, along with its traffic capacity, distribution characteristics, and levels of service, adequately represented the total 1973 trunk and local service airline environment (Figure 55) and is expected to represent its growth characteristics as well. Therefore, the fuel required, potential fuel savings, and aircraft demand resulting from the various fleet forecasts for the study market were extrapolated to the total U.S. domestic market.

3.2 Operational and Environmental Constraints

Operational and environmental constraints which were varied in the analyses using the Performance Evaluation Technique included aircraft operating procedures, airline planning load factors, levels of service provided, aircraft availability, fuel price, and fuel availability. Table 52 describes each of the thirty-five operating scenarios studied in terms of its operational constraints and its offering of competitive aircraft options.

Changes in the aircraft operating procedures to conserve fuel for a given aircraft type were evaluated by considering it as a "new" aircraft type. This new aircraft had increased range capabilities, as well as variations in DOC, fuel burned, and block times from the same aircraft operating under the baseline idealized conditions. This method was used to evaluate the benefits of both the fuel conserving operational improvements currently available within today's air traffic control environment, and the use of these procedures together with an improved air traffic control system assumed to be operational in 1980.

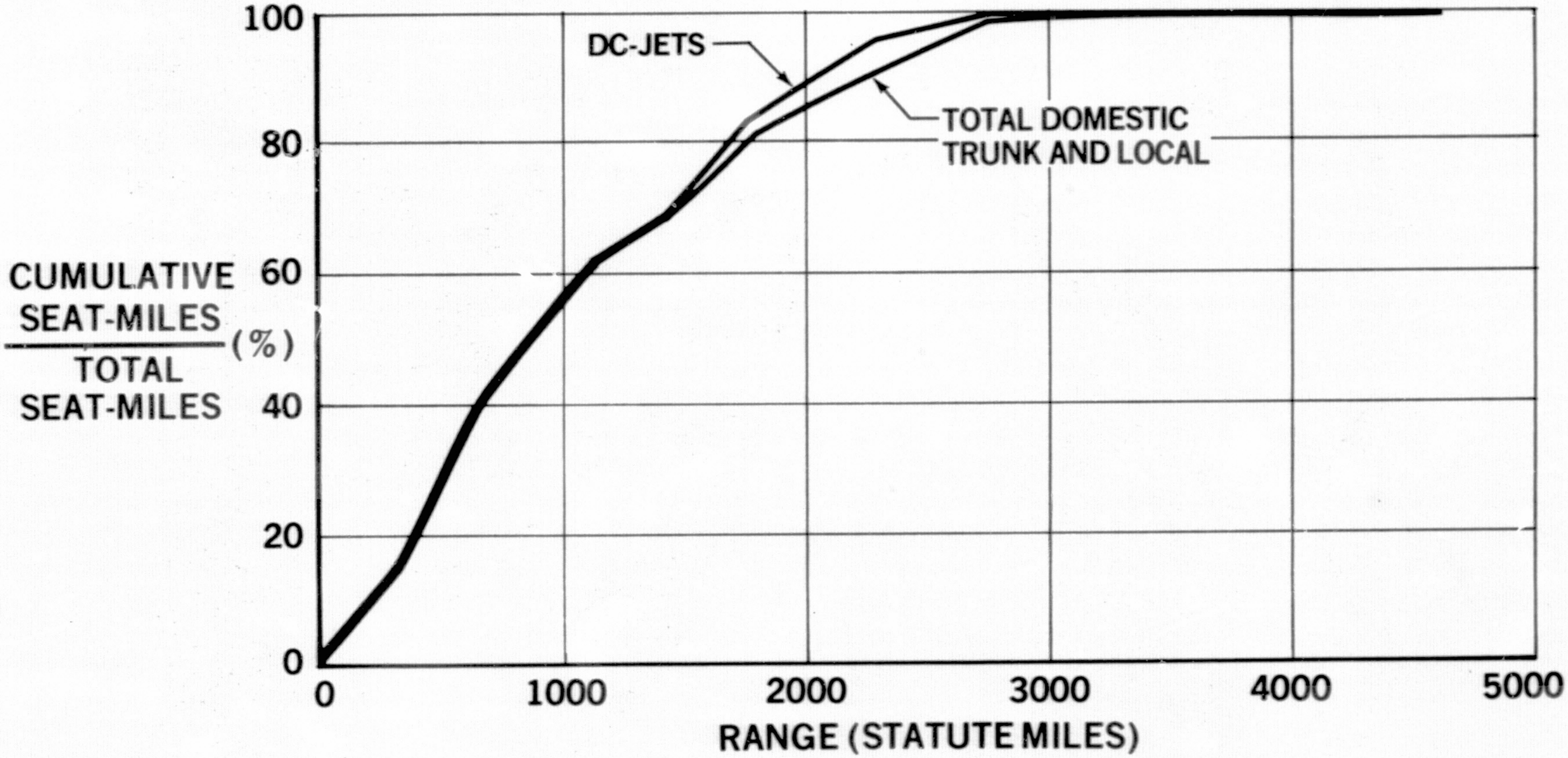


Figure 55. 1973 ASM DISTRIBUTION OF DC-JETS RELATIVE TO TOTAL MARKET AREA

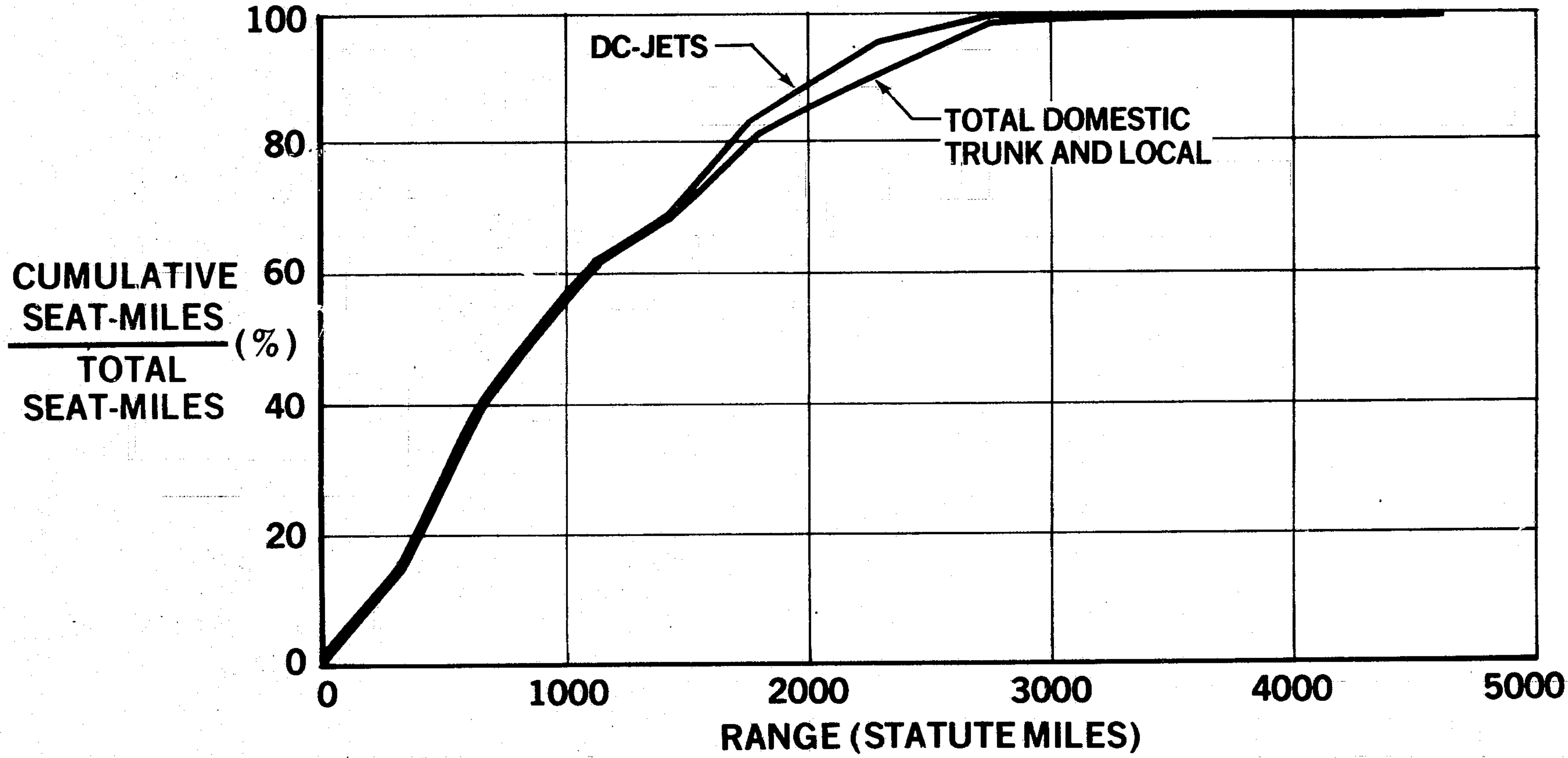


Figure 55. 1973 ASM DISTRIBUTION OF DC-JETS RELATIVE TO TOTAL MARKET AREA

TABLE 52

DEVELOPMENT OF FLEET FORECASTS – RUN SCHEDULE

OBJECTIVE – MAXIMIZE AIRLINE PROFIT

RUN NO.	TRAFFIC DEMAND		FLEET INVENTORY OPTIONS				AIRCRAFT INTRODUCTION DATES		AIRCRAFT OPERATING PROCEDURES		LEVEL OF SERVICE		LOAD FACTOR		FUEL AVAILABILITY		FUEL PRICE		FARES		SCENARIO DESCRIPTION
	BASE CASE	OTHER	EXIST. A/C	EXIST. MODS[1]	DERIV. A/C[2]	NEW NEAR TERM	DERIV. A/C	NEW NEAR TERM	CURRENT	FUEL CONSER.	MIN. TRIPS	MAX. TRIPS	1973 LEVEL	Δ L.F.	UNCON-STRAINED	1973 ALLOT-MENT	15¢	INC. PRICE	1973 FARES	OTHER	
1	X		X						X		X		X		X		X		X		15¢
2	X		X						X		X		X		X			30¢	X		Baseline @ 3 fuel prices 30¢
3	X		X						X		X		X		X			60¢	X		60¢
4	X		X						X		X	X	X		X			30¢	X		Hub constraints 30¢
5	X		X						X		X	X	X		X			60¢	X		60¢
6	X		X							Impr. Opers	X	X	X		X			60¢	X		Impr. Flt. Opers. – 1973 @ 60¢
7	X		X							Impr. ATC	X	X	X		X			60¢	X		Impr. Flt. Opers. plus 1980 Impr. ATC @ 60¢
8	X		X						X		X	X	X			X		30¢	X		Baseline @ 30¢ + fuel constraints
9	X		X	X					X		X	X	X			X		30¢	X		
10	X		X	X					X		X	X	X			X		30¢	X		Screening of retrofit options + fuel constraints @ 30¢
11	X		X	X					X		X	X	X			X		30¢	X		
12	X		X	S					X		X	X	X			X		30¢	X		Selected retrofit fleet + fuel constraints @ 30¢
13	X		X	S					X		X	X	X		X			30¢	X		Selected retrofit fleet without fuel constraints @ 30¢
14	X		X	S	X				X		X	X	X			X		30¢	X		Screening of derivative options + fuel constraints @ 30¢
15	X		X	S	S		X		X		X	X	X			X		30¢	X		Selected derivative fleet + fuel constraints @ 30¢
16	X		X	S	X				X		X	X	X		X			30¢	X		Screening of derivative options without fuel constraints @ 30¢
17	X		X	S	S		X		X		X	X	X		X			30¢	X		Selected derivative fleet without fuel constraints @ 30¢

S = SELECTED AIRCRAFT OPTIONS 1 – EXISTING MODS = RETROFITS 2 – IN-PRODUCTION MODS SCREENED WITH DERIVATIVE OPTIONS

TABLE 52 (Continued)

DEVELOPMENT OF FLEET FORECASTS - RUN SCHEDULE

OBJECTIVE - MAXIMIZE AIRLINE PROFIT

RUN NO.	TRAFFIC DEMAND		FLEET INVENTORY OPTIONS				AIRCRAFT INTRODUCTION DATES		AIRCRAFT OPERATING PROCEDURES		LEVEL OF SERVICE		LOAD FACTOR		FUEL AVAILABILITY		FUEL PRICE		FARES		SCENARIO DESCRIPTION
	BASE CASE	OTHER	EXIST. A/C	EXIST. MODS[1]	DERIV. A/C[2]	NEW NEAR TERM	DERIV. A/C	NEW NEAR TERM	CURRENT	FUEL CONSER.	MIN. TRIPS	MAX. TRIPS	1973 LEVEL	Δ L.F.	UNCON-STRAINED	1973 ALLOT-MENT	15¢	INC. PRICE	1973 FARES	OTHER	
18	X		X	S	S	X			X		X	X	X			X		30¢	X		Screening of N80 options + fuel constraints @ 30¢ and 60¢
19	X		X	S	S	X			X		X	X	X			X		60¢	X		
20		-10%	X	S	S	S		X	X		X	X		Lower 55%		X		30¢	X	X	
21	X		X	S	S	S		X	X		X	X	X			X		30¢	X		
22		+10%	X	S	S	S		X	X		X	X		Higher 70%		X		30¢	X	X	Selected N80s fleets + fuel constraints @ 30¢ and 60¢
23		-10%	X	S	S	S		X	X		X	X		Lower 55%		X		60¢	X	X	
24	X		X	S	S	S		X	X		X	X	X			X		60¢	X		
25		+10%	X	S	S	S		X	X		X	X		Higher 70%		X		60¢	X	X	
26	X		X	S	S	X			X		X	X	X		X			30¢	X		Screening of N80 options without fuel constraints @ 30¢ and 60¢
27	X		X	S	S	X			X		X	X	X		X			60¢	X		
28		-10%	X	S	S	S		X	X		X	X		Lower 55%	X			30¢	X	X	
29	X		X	S	S	S		X	X		X	X	X		X			30¢	X		
30		+10%	X	S	S	S		X	X		X	X		Higher 70%	X			30¢	X	X	Selected N80 fleets without fuel constraints @ 30¢ and 60¢
31		-10%	X	S	S	S		X	X		X	X		Lower 55%	X			60¢	X	X	
32	X		X	S	S	S		X	X		X	X	X		X			60¢	X		
33		+10%	X	S	S	S		X	X		X	X		higher 70%	X			60¢	X	X	
34	X		X	S	S	S		X	X		X	X		55%	X			30¢	X		Load factor variations with selected N80 fleet - no fuel constraints @ 30¢
35	X		X	S	S	S		X	X		X	X		70%	X			30¢	X		

The aircraft options offered to each scenario are shown in Table 53. The fleet forecasts were dependent upon the imposed annual aircraft availability constraints for each aircraft type. This included placing upper limits on the numbers of on-hand aircraft units, as well as their modification rates by type and year. Constraints were also established for the in-production modified and derivative aircraft as well as for the new near-term (1980) aircraft. These included forecasted market size, introductory year, and production rates. The production schedules for the 13 retrofit aircraft options are shown in Table 54.

3.3 Study Scenarios

Thirty-five alternative operating scenarios were developed, and each scenario was offered against the baseline 1973-1990 passenger demand forecasted in Phase I or a modification of this demand. When passenger demand was modified, it was either increased or decreased by 10 percent from the baseline forecast. The scenarios investigated were broken down into two groups.

- 8 operating scenarios with baseline aircraft only
  - with and without hub constraints
  - with and without fuel conserving operational procedures
- 27 operating scenarios to select the most promising aircraft options
  - modification options including retrofits
  - derivative aircraft
  - new near-term (1980) airplanes

The eight baseline scenarios investigated the impact of changes in operational constraints without any accompanying changes in the aircraft types offered. Only the existing Douglas airplanes in production (DC-9-30, DC-10-10, and DC-10-40) were assumed available to meet the subsequent demand. Twenty-seven additional operating scenarios were analyzed to select the most promising fuel conserving aircraft options. Each scenario included changes to the operational constraints as well as changes to the available aircraft options offered.

The forecasted results from the total of thirty-five alternative operating scenarios, (eight baseline plus twenty-seven aircraft option scenarios), were analyzed and compared on the basis of economic and operational factors. These factors included the aircraft types and numbers required, the total amount of

TABLE 53

AIRCRAFT TYPES OFFERED IN EACH SCENARIO

Scenarios

AIRCRAFT TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
DC-8-20	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-200P*						X	X																												
-20ATC							X																												
-20R									X			X	X	X		X																			
-20DR										X																									
-20ER											X																								
DC-8-50	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-500P*						X	X																												
-50ATC*							X																												
-50R									X																										
-50DR										X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-50ER											X																								
DC-8-61	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-610P*						X	X																												
-61ATC*							X																												
-61R									X																										
-61DR										X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-61ER											X																								
DC-9-10	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-100P*						X	X																												
-10ATC*							X																												
-10R									X	X	X																								
DC-9-30	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-300P*						X	X																												
-30ATC*							X																												
-30R									X	X	X	X	X	X		X																			
-30D1														X		X	X									X	X	X	X	X	X	X	X	X	X
-30D2														X		X																			
-30D3														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DC-10-10	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-100P*						X	X																												
-10ATC*							X																												
-10R									X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X										
-10M														X		X																			
-10D														X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DC-10-40	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
-400P						X	X																												
-40ATC							X																												
-40R									X	X	X	X	X	X		X																			
-40M														X		X																			
-40D														X		X	X									X	X								
$N80-2.15_{15}$																		X	X							X	X								
$N80-2.15_{30}$																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
$N80-2.15_{60}$																		X	X							X	X								
$N80-2.15_{MF}$																		X	X							X	X								
$N80-2.30_{15}$																		X	X							X	X								
$N80-2.30_{30}$																		X	X	X	X	X	X	X	X	X	X								
$N80-2.30_{60}$																		X	X							X	X								
$N80-2.30_{MF}$																		X	X							X	X								
$N80-4.30_{15}$																		X	X							X	X								
$N80-4.30_{30}$																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
$N80-4.30_{60}$																		X	X	X	X	X	X	X	X	X	X				X	X	X		
$N80-4.30_{MF}$																		X	X							X	X								
NO. A/C TYPES	7	7	7	7	7	7	14	7	14	14	14	13	13	20	12	20	13	24	24	16	16	16	16	16	16	25	25	14	14	14	15	15	15	14	14

*DESIGNATORS FOR BASELINE AIRCRAFT WHICH REFLECT FUEL CONSERVING OPERATING PROCEDURES:

OP = IMPROVED FLIGHT OPERATIONS   ATC = IMPROVED FLIGHT OPERATIONS PLUS IMPROVED (1980) ATC SYSTEM

TABLE 54

RETROFIT AVAILABILITY SCHEDULE

Baseline Airplanes	Units in U.S. Domestic Fleet - 1973	Retrofitted Airplanes Available By Year**			
		1978	1979	1980	1981
DC-8-20	34	--	14	14	6
DC-8-50	40	--	21	19	--
DC-8-61	45	--	17	19	9
DC-9-10	90	26	26	26	12
DC-9-30	239	71	71	71	26
DC-10-10	115*	37	37	37	4
DC-10-40	35*	11	11	11	2

*Estimated number of airplanes available for retrofitting in U.S. domestic fleet in 1978.

**Retrofit aircraft are designated as "R", "DR", or "ER" - Schedule for DC-8 models applies to only one retrofit option at a time.

fuel burned, number of trips needed, profit generated, revenue passenger-miles flown, and the selected fleet-mix's capacity for satisfying the projected market demand during the years 1973-1990. The results of each scenario were calculated annually for the total fleet and by individual aircraft type.

3.4 Baseline Operating Scenarios

Differences in the eight baseline operating scenarios, offering only the existing Douglas airplanes to meet subsequent aircraft demand, are outlined. The operational conditions that were varied from scenario to scenario are underlined and the number of cases examined under each condition is given in parenthesis.

- Baseline pre-energy crisis scenario with fuel price at 15¢ per gallon (1)
- Baseline scenario with fuel price at 30¢ and 60¢ per gallon (2)
- Baseline scenario with hub constraints - fuel at 30¢ and 60¢ per gallon (2)
- Baseline scenario with allocated fuel at 1973 levels - fuel at 30¢ per gallon (1)
- Implementation of fuel conserving flight operations with and without ATC improvements - fuel at 60¢ per gallon (2)

The first baseline scenario was developed to simulate the airline operating environment in 1973. This scenario represented the existing on-hand and new production Douglas equipment operating through 1990 over the DC-Jet route network in an unconstrained fuel environment. It also reflected 1973 load factors and operational procedures, 1973 frequencies as a minimum, 1973 fare levels, and the lowest NASA-specified fuel price of 15 cents per gallon. Only existing Douglas airplanes in production in 1973 were allowed to meet the additional aircraft demand through 1990. The fleet-mix selected for this scenario satisfied 100 percent of the forecasted revenue passenger-mile demand.

This case reflected a pre-energy crisis environment for the airlines throughout the forecast period. Since fuel was at 15 cents per gallon, this scenario provided the upper limit for fuel demand on the route system from 1973-1990. All the other operating scenarios were analyzed at a fuel price of either

30 cents or 60 cents per gallon. The RECAT Study contractors assumed that a fuel price of 30 cents per gallon in constant 1973 dollars represented a realistic average price during the study years. A higher fuel price of 60 cents per gallon in constant 1973 dollars was used to reflect an average upper limit on fuel price over the forecast period.

3.4.1 Baseline Operational Changes - The variations in the operational constraints outlined in Section 3.4 included changing fuel price from 15 cents per gallon to 30 cents and 60 cents per gallon, holding available fuel through 1990 to the 1973 level, implementing hub constraints, and improving flight operations to conserve fuel.

Hub Constraints - Two baseline scenarios, one at a fuel price of 30 cents per gallon and the other at 60 cents per gallon, considered the effect of implementing hub constraints, (maximum frequency limitations) at selected hub airports over the forecast period. The hubs selected and their growth rates were discussed in Section 1.8.4.

Fuel Conserving Operating Procedures - The impact of fuel conservative operational variations, relative to the idealized handbook flight profiles, were analyzed for the baseline aircraft. The variations included alternative flight operations, involving both navigational and aircraft management procedures, as well as alternative ground operations. These operational procedures were assessed at two levels - those that could be implemented without a significant change in the present Air Traffic Control (ATC) System, and those that would require significant ATC changes. The first scenario involved the use of long range flight profiles including long range climb and cruise procedures and represented the most fuel conserving level possible in today's ATC system. In addition to the first level of fuel conserving flight operations, the second scenario also assumed an improved ATC system operational in 1980. No attempt was made to assess the cost of implementing these improvements to the air traffic control system since this was outside the scope of the study. Instead, assumptions were made by the contractors and NASA as to the possible capabilities of the system in 1980. These included the use of aircraft cruise climb procedures and four-dimensional area navigation (4-DRNAV), which together allow more optimum flight paths with minimum delay time.

3.4.2 Scenario Reference Cases

Once the hub constraints were implemented, they were retained for all the improved flight operations scenarios as well as for all the twenty-seven aircraft option scenarios. The baseline hub constraint scenarios with fuel at 30 cents and 60 cents per gallon were chosen as the primary reference cases against which the twenty-seven alternative scenarios were quantitatively compared because they more accurately represented the real airline environment of major airport saturation anticipated during the study period.

3.5 Fleet Forecast Results of Eight Baseline Operating Scenarios - DC-Jet Network

3.5.1 Pre-Energy Crisis Baseline Scenario (Fuel at 15 Cents Per Gallon)

The fleet forecast developed for the baseline pre-energy crisis scenario with fuel at 15 cents per gallon required a total fleet of 559 aircraft in 1973, 600 in 1980 when the goal load factor of 58 percent was first achieved, and 801 by 1990. The fleet carried all the forecasted revenue passenger-mile demand throughout the study period. The fuel burned by the fleet totalled 6.8 million tons in 1973, 8.7 million tons in 1985, and by 1990 it was 10.1 million tons. Over the entire study period, the fleet forecasted for this scenario consumed a total of 144.5 million tons of fuel and generated a gross operating profit of $24.3 billion. For this study the terms gross operating profit and profit were defined as total revenue less total operating costs.

3.5.2 Baseline Scenario With Fuel at 30 Cents and 60 Cents Per Gallon

Only fuel price was increased in the next two baseline scenarios, from 15 cents to 30 cents and then to 60 cents per gallon. The fleets required to maximize airline profits under these two fuel price scenarios carried all the passenger traffic and burned approximately the same amount of total fuel, 144.1 and 144.0 million tons respectively, as the pre-energy crisis scenario did during 1973-1990.

However, profit over the forecast period decreased by almost 24 percent to $18.6 billion with a fuel price of 30 cents per gallon and by 71 percent to $7.1 billion when fuel was at 60 cents per gallon. Fleet sizes stayed approximately the same through 1985 as those of the 15 cents per gallon scenario, but decreased by 1990 to 783 and 785 airplanes respectively.

3.5.3 Baseline Scenarios at 30 Cents and 60 Cents Per Gallon With Hub Constraints

In order to assure airline realism in the study, the hub constraints discussed in Section 1.8.4 were added to the two baseline scenarios with fuel prices of 30 cents and 60 cents per gallon. In both hub-constrained fleet forecasts, passenger RPM's decreased by about 3-1/2 percent or by 38.8 and 40.5 billion RPM's respectively during the 1973-1990 study period as shown in Figure 56. Fleet sizes in 1980 were 594 airplanes for both forecasts; in 1990 they were 718 and 717 respectively. In order to effectively compare the results of these forecasts with the non hub-constrained 30 cents and 60 cents scenarios, it was necessary to compare the fuel consumption and profit generation in terms of passenger volume. This type of efficiency comparison will continue throughout the study since the RPM's which were performed for each operating scenario were different. Therefore, fuel burns of the fleet forecasts were compared on the basis of pounds of fuel per RPM, and profit was compared on the basis of dollars of profit per RPM. When the hub constraints were added to the two baseline scenarios with fuel prices of 30 and 60 cents per gallon, the fuel burned and profit generated per RPM did not change noticeably from that achieved by the non hub-constrained scenarios at the same fuel price, as shown in Figure 57.

3.5.4 Baseline Scenario With Allocated Fuel

This scenario measured the effect of limiting fuel availability for each year in the forecast to the 1973 level. The fuel price for this operating scenario was 30 cents per gallon. The RPM's carried during 1973-1990 decreased by 15 percent from the baseline reference case, (the hub-constrained scenario at 30 cents per gallon). It should be noted that once the hub constraints were implemented in the previous two baseline scenarios, these constraints were continued in each subsequent operating scenario. This fuel allocated fleet forecast generated a little over 4 percent less profit per RPM while the fuel consumed was 3 percent higher per RPM than for the baseline hub scenario. This was due to the lower RPM performance and the addition of very few new more fuel-efficient baseline aircraft to the fleet. However, in total fuel burned over the forecast period, the forecasted fleet in a fuel constrained environment consumed 17.4 million tons less, a 12-1/2 percent reduction. This was achieved by performing 15 percent less RPM's. Therefore, even though the fleet mix changed slightly over time, the total fleet size required for this forecast remained essentially constant at about 559 airplanes from 1973-1990.

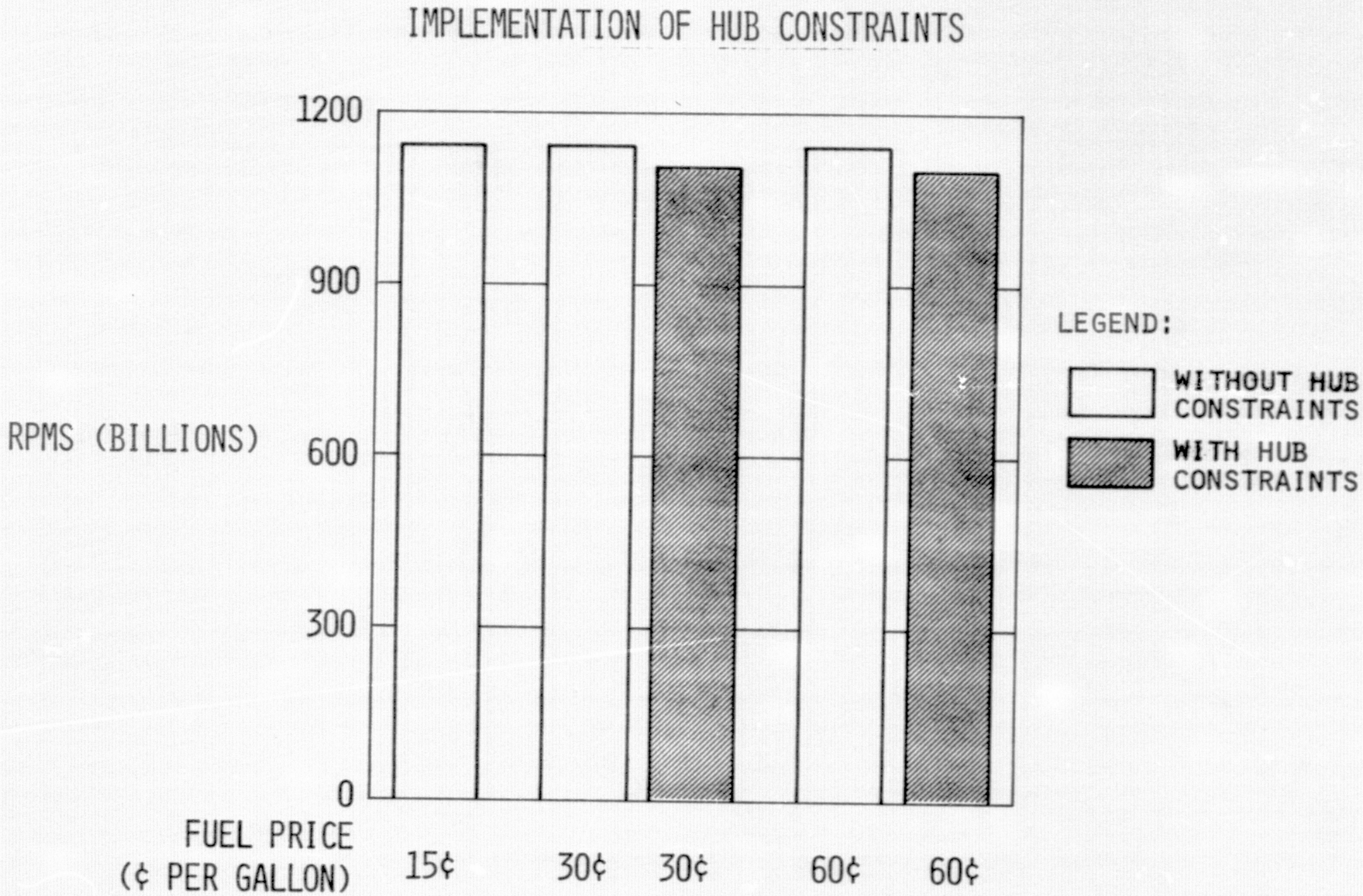


Figure 56. Baseline Aircraft Fleet Results

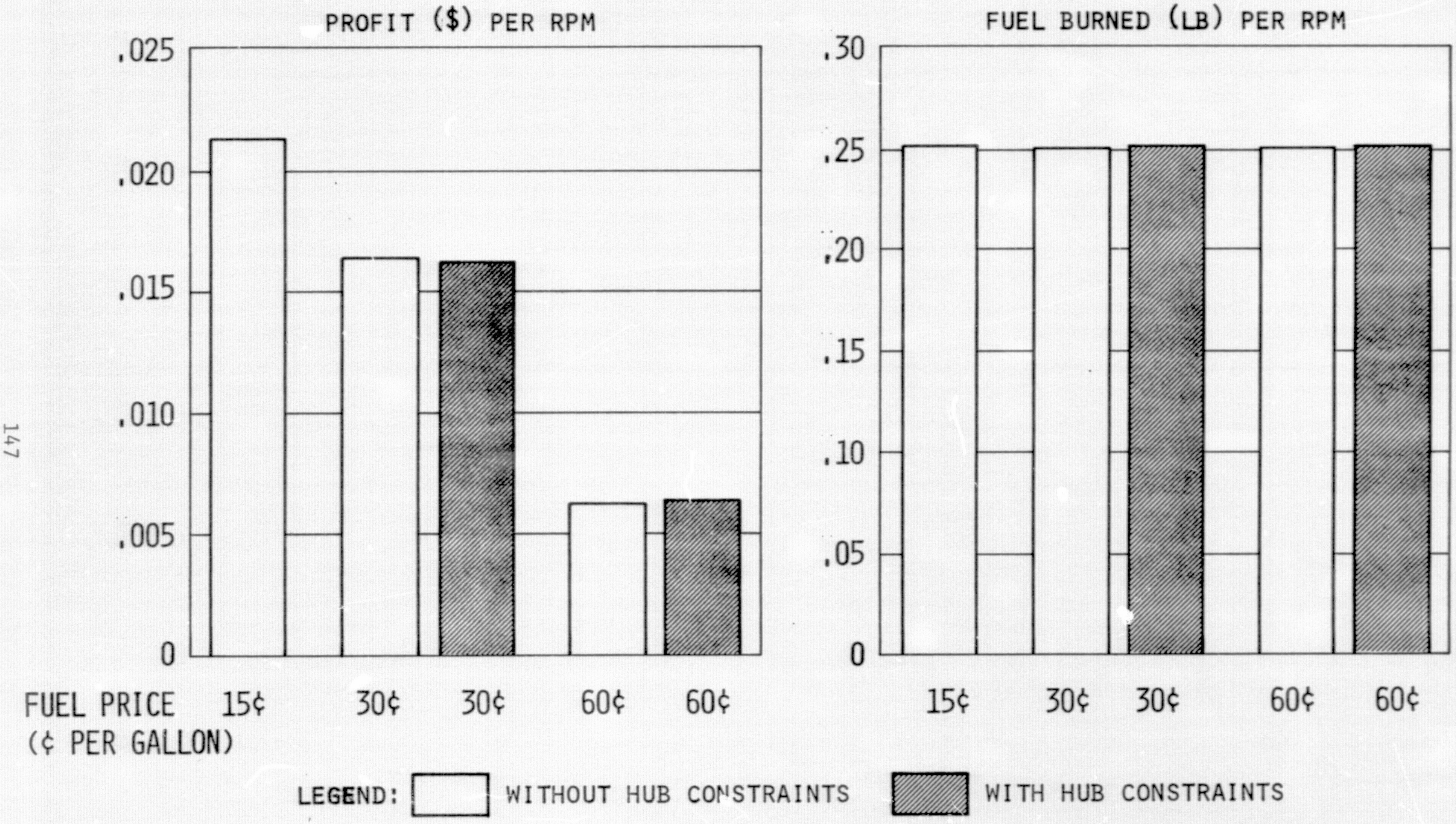


Figure 57. Baseline Aircraft Fleet Results

3.5.5 Implementation of Fuel Conserving Operational Procedures at 60 Cents Per Gallon

The first level of improved flight operations that were examined to conserve fuel involved those procedures that could be achieved by the airlines under the present ATC system. The second level involved the reduction in fuel consumption that could be attained using the procedures initiated for the first level plus the potential fuel savings that would result from operating under an improved air traffic control system assumed available in 1980. There was little change in the RPM's generated by either fleet forecast as shown in Figure 58 relative to the hub-constrained scenario with fuel at 60 cents per gallon. However, with the currently available fuel conserving operational procedures, profit per RPM decreased 8 percent but, importantly, fuel savings per RPM increased by 5 percent during 1973-1990. Profit was down in this scenario due to the increased block times resulting from slowing down to conserve fuel. These increased block times had a strong impact upon both the direct and indirect operating costs.

Under a 1980 improved ATC operating scenario, profit over the forecast period improved by almost 13 percent and fuel savings increased by 7.5 percent relative to the baseline reference case. Fuel savings for this scenario during the period that the improved ATC was operational, from 1980-1990, were over 10 percent relative to the reference case. The total fuel burned by this fleet in 1990 was 8.2 million tons compared to almost 9.2 million tons for the reference hub-constrained scenario, while generating almost an equivalent number of RPM's. Therefore, an improved ATC system that could achieve significant reductions in flight delays does appear to be a worthwhile goal in terms of fuel conservation. However, the benefits of these potential fuel savings would have to be evaluated against the cost of improving the system. This detailed evaluation was beyond the scope of the present study.

3.5.6 Summary of Fleet Forecast Results for the Baseline Operating Scenarios

Table 55 summarizes the results from the fleet forecasts for each of the eight baseline operating scenarios. The revenue passenger-miles and the required aircraft units are given for each scenario. Fuel savings are shown for the fuel allocated and fuel conserving operational scenarios relative to the study reference cases. These referenced cases were the hub-constrained scenarios with fuel prices of 30 cents and 60 cents per gallon.

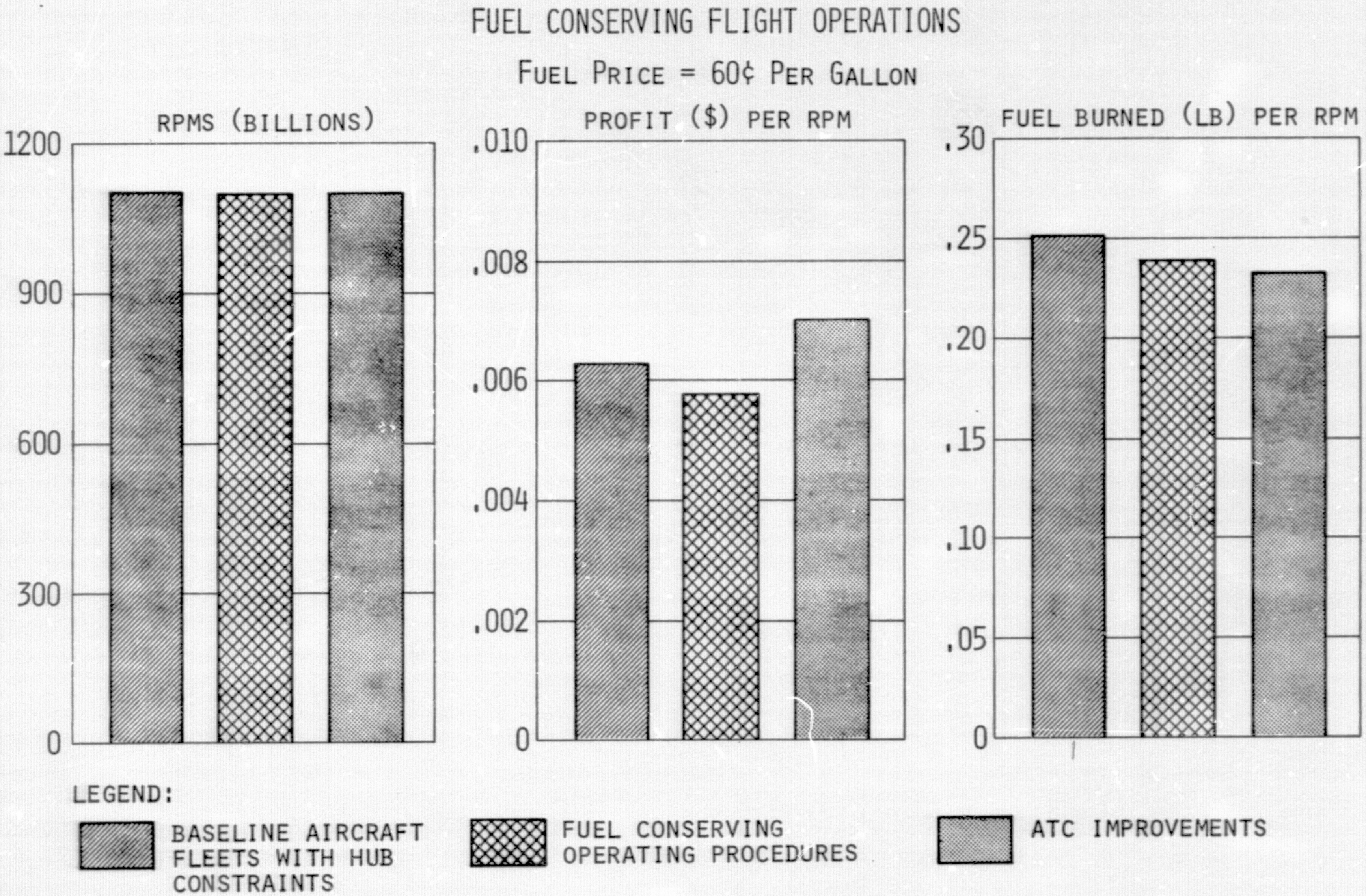


Figure 58. Baseline Aircraft Fleet Results

TABLE 55

COMPARATIVE FLEET FORECAST RESULTS

BASELINE SCENARIOS	RPM'S (Billions)		ANNUAL FLEET SIZE (Number of Airplanes)				FUEL SAVINGS/RPM (Percent)	
	1973-1990	1980-1990	1973	1980	1985	1990	1973-1990	1980-1990
15¢ (Pre-Energy Crisis)	1144.222	799.627	559	600	675	801	--	--
30¢/Gallon Fuel	1144.222	799.627	559	600	674	783	--	--
60¢/Gallon Fuel	1144.222	799.627	559	600	670	785	--	--
Hub-Constrained @ 30¢	1105.469	763.816	559	594	647	718	--	--
Hub-Constrained @ 60¢	1103.723	762.065	559	594	645	717	--	--
Fuel Allocated @ 30¢	940.371	605.222	559	559	560	559	-2.9	6.0
Fuel Consv. Flt. Opers. (1973) @ 60¢	1102.295	761.142	559	629	684	757	4.9	6.3
Impr. ATC (1980) @ 60¢	1102.478	761.866	559	608	661	730	7.5	10.1

3.6 Alternative Aircraft Option Scenarios

Twenty-seven operating scenarios were used to select the most promising fuel conserving aircraft options. Each scenario included an appropriate set of aircraft offerings from which the best fleet-mix was selected. These sets of aircraft options were developed to reflect the typical changes that will occur in an airline's aircraft requirements and fleet composition over a seventeen year period, 1973-1990. Their introduction dates were also time-phased to represent the order in which the various aircraft options would become available in the market place.

The retrofit options, (modifications to the existing Douglas airplanes in the fleet), were screened first against the seven baseline aircraft. Next the modification options, (existing airplane types modified in-production), and the derivative aircraft were screened against both the baseline airplanes and the selected retrofit options. Finally, the new near-term 1980 technology aircraft were screened against the baseline airplanes as well as the selected retrofit, modification and derivative options.

The twenty-seven alternative operating scenarios that were studied are outlined by three general sets of aircraft offerings. The operational constraints that were varied in the scenarios are listed, and the number of cases examined under each condition are given in parentheses.

- Implementation of the retrofit options with fuel at 30 cents per gallon
  - Total (both drag reduction and engines) retrofits screened - fuel constrained environment only (1)
  - Drag reduction retrofits screened - fuel constrained environment only (1)
  - Engine retrofits screened - fuel constrained environment only (1)
  - Initially selected retrofits - both fuel environments (2)
- Implementation of <u>selected retrofits</u> with <u>modification and derivative options</u> - fuel at 30 cents per gallon, both fuel environments.
  - Initially selected retrofits screened with modifications and derivatives (2)
  - Selected modifications and derivatives (2)

- o Implementation of selected mod options including retrofits and selected derivatives, with new near-term aircraft - fuel prices of 30 cents and 60 cents per gallon, both fuel environments.
  - Selected mod options, and derivatives screened with new near-term aircraft (4)
  - Selected mod options, derivatives, and new near-term aircraft (4)
  - Investigated the effect of varying the baseline traffic demand (8)
    - + 10 percent RPM demand
    - - 10 percent RPM demand
  - Analyzed the impact of load factor - without fuel constraints at a fuel price of 30 cents per gallon (2)
    - 55 percent goal load factor
    - 70 percent goal load factor

3.6.1 Alternative Scenario Operational Changes

The retrofit aircraft options were screened only under a fuel constrained environment. Since the airlines are not particularly favorable toward the retrofitting of old aircraft, these aircraft options were tested under a fuel availability environment which might convince the airlines to retrofit if the options proved to be economically and operationally viable.

The modification, derivative, and new near-term airplanes were screened under both the fuel environments, one with a constrained fuel supply and the other with an unlimited fuel supply. This was done to determine those aircraft options that would be the most viable under either fuel situation.

The fleets forecasted for each offering of aircraft options were comprised of those aircraft options selected as the most fuel conserving and economically viable from the screening procedures. Some selected retrofits were dropped when screened with the modification and derivative options, while other retrofits previously selected were eliminated when tested against the new near-term airplanes.

Operational changes, other than the fuel environments and the different offerings of options, were analyzed after the best fleet-mixes combining all the selected aircraft options had been determined. This provided results that more accurately reflected the real airline environment of changing fleet compositions over a long period of time, 1973-1990.

Scenario Reference Cases - As stated in Section 3.4.2, the primary reference cases for this study were the baseline hub constraint scenarios with fuel at 30 cents and 60 cents per gallon. Results and fuel savings of the fleet forecasts developed from the twenty-seven alternative operating scenarios were measured against the results of the hub-constrained scenarios.

3.7 Fleet Forecast Results of Alternative Aircraft Option Scenarios - DC-Jet Network

3.7.1 Retrofit Options

Three fleet forecasts were made to initially screen the baseline retrofits because each DC-8 airplane studied had three potential retrofit options. These forecasts were made under a fuel constrained environment as the retrofitted aircraft were principally designed to obtain fuel savings independent of cost considerations. Since the DC-9 and DC-10 airplane types did not have multiple retrofit options, they competed with each other and the offered DC-8 retrofits in each forecast. First, the three DC-8R's (total retrofit packages including drag and engine modifications) were offered against the baseline aircraft plus the DC-9 and DC-10 retrofits. Then the DC-8DR's (drag reduction retrofits), and lastly the DC-8ER's (engine retrofits) were tested against the baseline aircraft plus the DC-9 and DC-10 retrofits. The retrofit options chosen from this screening process are shown in Table 56.

TABLE 56

RESULTS OF INITIAL MODIFICATION SCREENING

DC-8-20R	DC-8-20DR	DC-8-20ER
DC-8-50R	DC-8-50DR	DC-8-50ER
DC-8-61R	DC-8-61DR	DC-8-61ER
	DC-9-10R	
	DC-9-30R	
	DC-10-10R	
	DC-10-40R	

= Selected Option

From the various DC-8 retrofit options, the market selected the DC-8-20R, DC-8-50DR, and DC-8-61DR. Each selected aircraft provided, for its type, the highest combination of potential profit increase and fuel savings. The DC-9-10R was the only retrofit of the DC-9 and DC-10 airplane types that was not selected by the market. The fuel savings it offered did not offset higher operating costs than those of the baseline DC-9-10. Fleet forecasts under both fuel environments were then made offering both the baseline airplanes and the six selected retrofits (Table 56) to the market. The profit improvement and fuel savings resulting from these fleets are shown in Figure 59.

The RPM's performed by the selected fleet-mix under a fuen constrained scenario were over 10 percent less during the period 1973-1990 than those for the reference scenario with an unlimited fuel supply. The number of airplanes required in 1980 was 566, but by 1990 only 580 units were needed in this fleet since the ability to satisfy all the RPM growth was reduced by the restricted fuel availability. Fuel savings achieved with the selected retrofit options were over 5 percent during the period 1980-1990, but as the mods were not available until 1978-1980, fuel savings over the total forecast period were only 3 percent.

The fleet-mix selected for an unlimited fuel environment produced the same RPM's as the reference scenario in which only the hub constraints limited the full performance of the forecasted annual traffic demands. Fuel savings achieved with the retrofit options were only 1-1/2 percent from 1973-1990 and 2 percent from 1980-1990. As expected, the savings achieved with the retrofit options in this fleet-mix were less than the savings realized with them under the fuel constrained environment. This was due to the increased value applied in the analysis to fuel savings in a fuel limited environment. Profit per RPM in the unconstrained fuel environment was approximately the same as for the reference scenario. In the fuel constrained environment, profit per RPM was 4 percent less than for the reference case. However, in comparing the results of this scenario to those for the baseline scenario with fuel allocations, the addition of the selected retrofit options into the fleet did increase profit by almost 1/2 percent, but, more importantly, they provided fuel savings of 6 percent.

3.7.2 Modification and Derivative Options

Fleet forecasts were developed under both fuel environments to screen the modification and derivative options against the baseline airplanes and

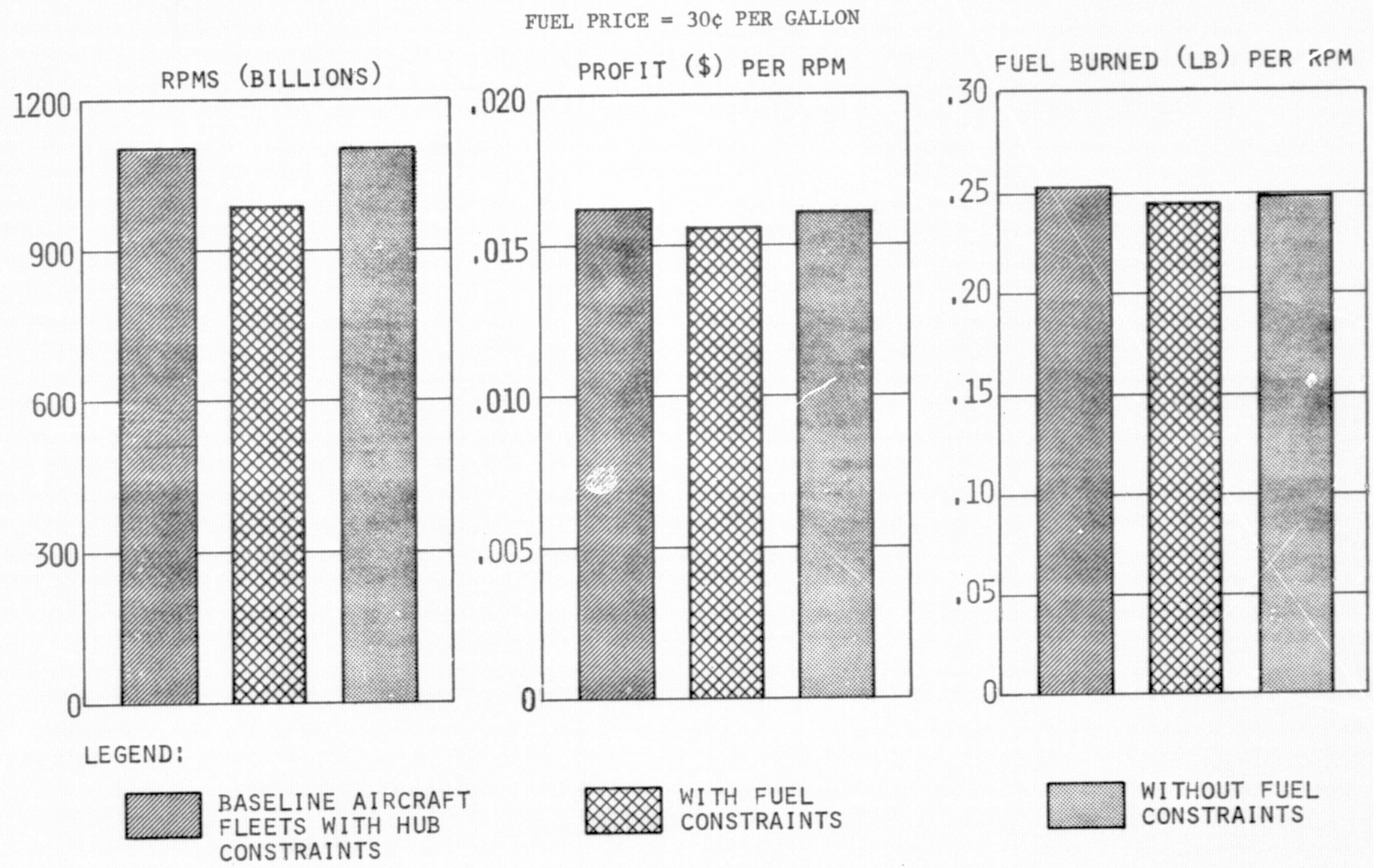


Figure 59. Fleet Forecast Results With Selected Retrofit Options

selected retrofit options. The previously desirable DC-8-20R, DC-9-30R, and DC-10-40R aircraft were dropped by the market in favor of the more economic derivative options which were also better sized for the market at the time of their introduction. Nor were the in-production modification options (DC-10-10M and DC-10-40M) viable in the study market due to their high total operating costs. The DC-8-50DR, DC-8-61DR, and DC-10-10R retrofit options were still desired by the market along with the selected derivative options shown in Table 57.

TABLE 57

RESULTS OF MODIFICATION AND DERIVATIVE OPTION SCREENING

With Fuel Constraints	Without Fuel Constraints
DC-9-30D1	$\boxed{\text{DC-9-30D1}}$
DC-9-30D2	DC-9-30D2
$\boxed{\text{DC-9-30D3}}$	$\boxed{\text{DC-9-30D3}}$
DC-10-10M	DC-10-10M
$\boxed{\text{DC-10-10D}}$	$\boxed{\text{DC-10-10D}}$
DC-10-40M	DC-10-40M
DC-10-40D	$\boxed{\text{DC-10-40D}}$

$\boxed{\quad\quad}$ = Selected Option

Results of the fleet forecasts are shown in Figure 60. The selected fleet-mix for the fuel constrained scenario performed only 90 percent of the RPM's produced by the reference case from 1973-1990. However, it is important to point out that by the year 1985 over 14 percent of the passenger demand was not served and by 1990 over 25 percent of the demand was turned away when the fuel constrained environment was imposed. The fleet-mix selected in an unlimited fuel availability scenario carried 1 percent more RPM's than the reference case over the forecast period. This was because the airplanes selected for this fleet were better sized for the market and were thus able to carry more traffic in some of the hub-constrained markets, and still meet the frequency limitations.

selected retrofit options. The previously desirable DC-8-20R, DC-9-30R, and DC-10-40R aircraft were dropped by the market in favor of the more economic derivative options which were also better sized for the market at the time of their introduction. Nor were the in-production modification options (DC-10-10M and DC-10-40M) viable in the study market due to their high total operating costs. The DC-8-50DR, DC-8-61DR, and DC-10-10R retrofit options were still desired by the market along with the selected derivative options shown in Table 57.

TABLE 57

RESULTS OF MODIFICATION AND DERIVATIVE OPTION SCREENING

With Fuel Constraints	Without Fuel Constraints
DC-9-30D1	$\boxed{\text{DC-9-30D1}}$
DC-9-30D2	DC-9-30D2
$\boxed{\text{DC-9-30D3}}$	$\boxed{\text{DC-9-30D3}}$
DC-10-10M	DC-10-10M
$\boxed{\text{DC-10-10D}}$	$\boxed{\text{DC-10-10D}}$
DC-10-40M	DC-10-40M
DC-10-40D	$\boxed{\text{DC-10-40D}}$

$\boxed{}$ = Selected Option

Results of the fleet forecasts are shown in Figure 60. The selected fleet-mix for the fuel constrained scenario performed only 90 percent of the RPM's produced by the reference case from 1973-1990. However, it is important to point out that by the year 1985 over 14 percent of the passenger demand was not served and by 1990 over 25 percent of the demand was turned away when the fuel constrained environment was imposed. The fleet-mix selected in an unlimited fuel availability scenario carried 1 percent more RPM's than the reference case over the forecast period. This was because the airplanes selected for this fleet were better sized for the market and were thus able to carry more traffic in some of the hub-constrained markets, and still meet the frequency limitations.

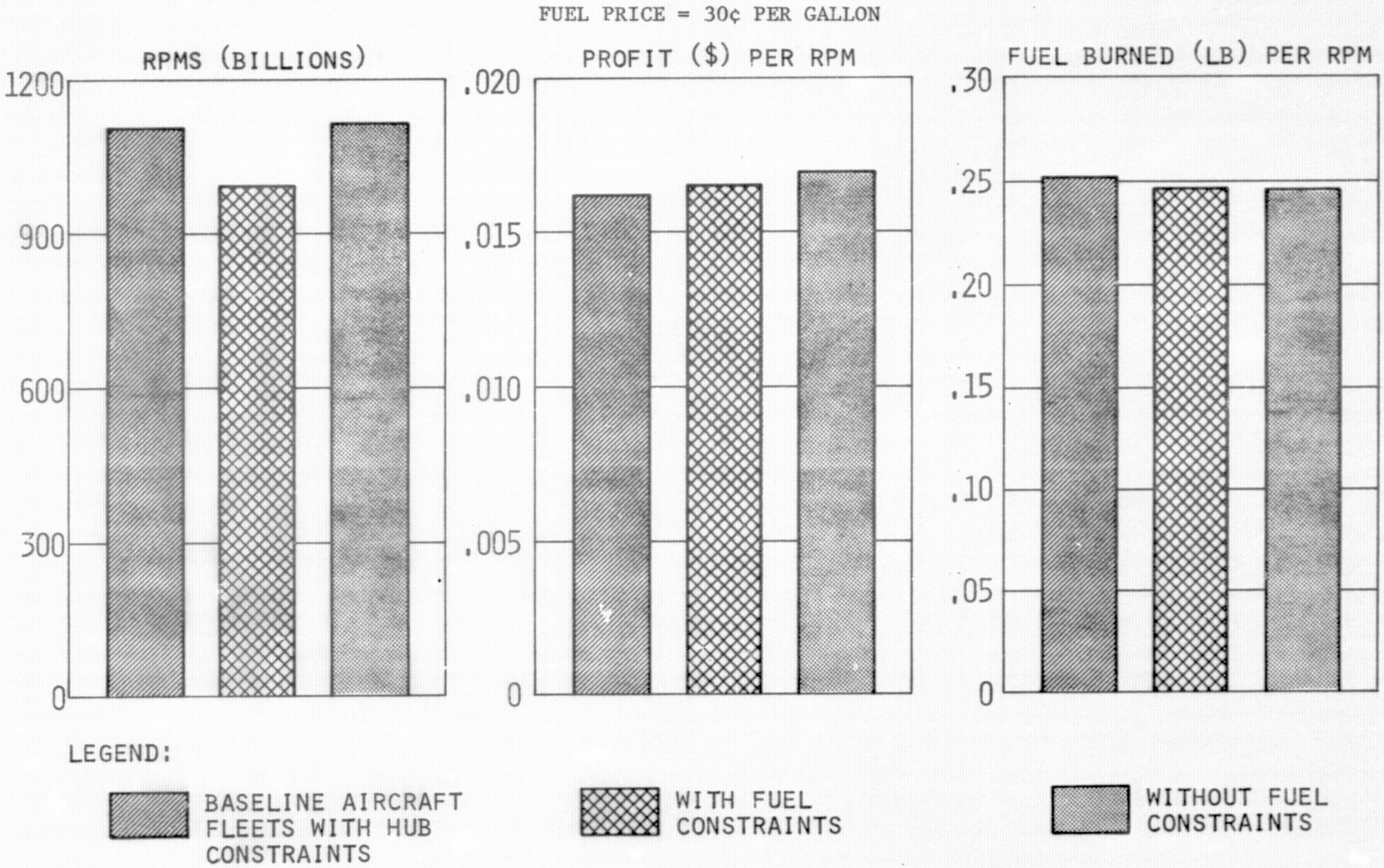


Figure 60. Fleet Forecast Results With Selected Modifications Including Retrofits, and Derivative Options

Five hundred and seventy-five aircraft were required by the fuel constrained fleet in 1980 and by 1990 only 594 airplanes were needed. In contrast, the unlimited fuel fleet required 598 units in 1980 and 727 airplanes in 1990. Fuel savings for the fuel allocated scenario were 4.5 percent over the forecast period, 1973-1990, and 7.3 percent during 1980-1990. With the selected retrofits and derivatives in the unlimited fuel scenario, fuel savings of 4.7 percent were achieved over the entire study period and 7 percent from 1980-1990. Profit per RPM increased almost 2 percent for the fuel constrained scenario and over 4 percent for the unconstrained fuel environment over the reference case during 1973-1990.

3.7.3 New Near-Term (1980) Aircraft

Four fleet forecasts were developed to screen the selected mod options, including the viable retrofits as well as the selected derivatives, and the twelve new near-term airplanes. Two scenarios with fuel prices of 30 cents and 60 cents per gallon were considered in a fuel constrained environment while the other two scenarios had an unlimited fuel supply at the same two fuel prices. The N80 aircraft that were selected under both fuel environments are shown in Table 58. Fuel price did not affect the selections shown. In either fuel environment the N80-2.15_{30} proved to be a very viable airplane in the study market.

Results of the fleet forecasts are shown in Figures 61 and 62. Both of the N80 fleet mixes selected for the scenarios with no fuel constraints at 30 cents and 60 cents per gallon produced more RPM's from 1973-1990 than the hub-constrained reference scenario, 1 percent and 1/2 percent respectively. Revenue passenger-miles over the forecast period for the fuel constrained scenarios with 30 cents and 60 cents per gallon fuel decreased from the reference case by 8 percent and 9 percent respectively. Profit per RPM during this period increased by 6-7 percent for the scenarios with fuel at 30 cents per gallon and 33-35 percent for those scenarios with fuel at 60 cents per gallon. Profit improvement achieved with the more economic derivative and new near-term aircraft options for the 60 cent scenarios was much higher than that for the 30 cent scenarios. This was because in the higher fuel price environment these aircraft types became more viable, increasing overall fleet profitability.

Fuel savings have increased with the addition of each selected group of options. For all four fleet mixes with the selected N80's, fuel savings were between

TABLE 58

RESULTS OF NEW NEAR-TERM AIRCRAFT SCREENING

WITH FUEL CONSTRAINTS		WITHOUT FUEL CONSTRAINTS
N80 - 2.15_{15}	200 Psgr; 1,500 NM	N80 - 2.15_{15}
$\boxed{\text{N80 - }2.15_{30}}$		$\boxed{\text{N80 - }2.15_{30}}$
N80 - 2.15_{60}		N80 - 2.15_{60}
N80 - 2.15_{MF}		N80 - 2.15_{MF}
N80 - 2.30_{15}	200 Psgr; 3,000 NM	N80 - 2.30_{15}
$\boxed{\text{N80 - }2.30_{30}}$		N80 - 2.30_{30}
N80 - 2.30_{60}		N80 - 2.30_{60}
N80 - 2.30_{MF}		N80 - 2.30_{MF}
N80 - 4.30_{15}	400 Psgr; 3,000 NM	N80 - 4.30_{15}
$\boxed{\text{N80 - }4.30_{30}}$		$\boxed{\text{N80 - }4.30_{30}}$
$\boxed{\text{N80 - }4.30_{60}}$		$\boxed{\text{N80 - }4.30_{60}}$
N80 - 4.30_{MF}		N80 - 4.30_{MF}

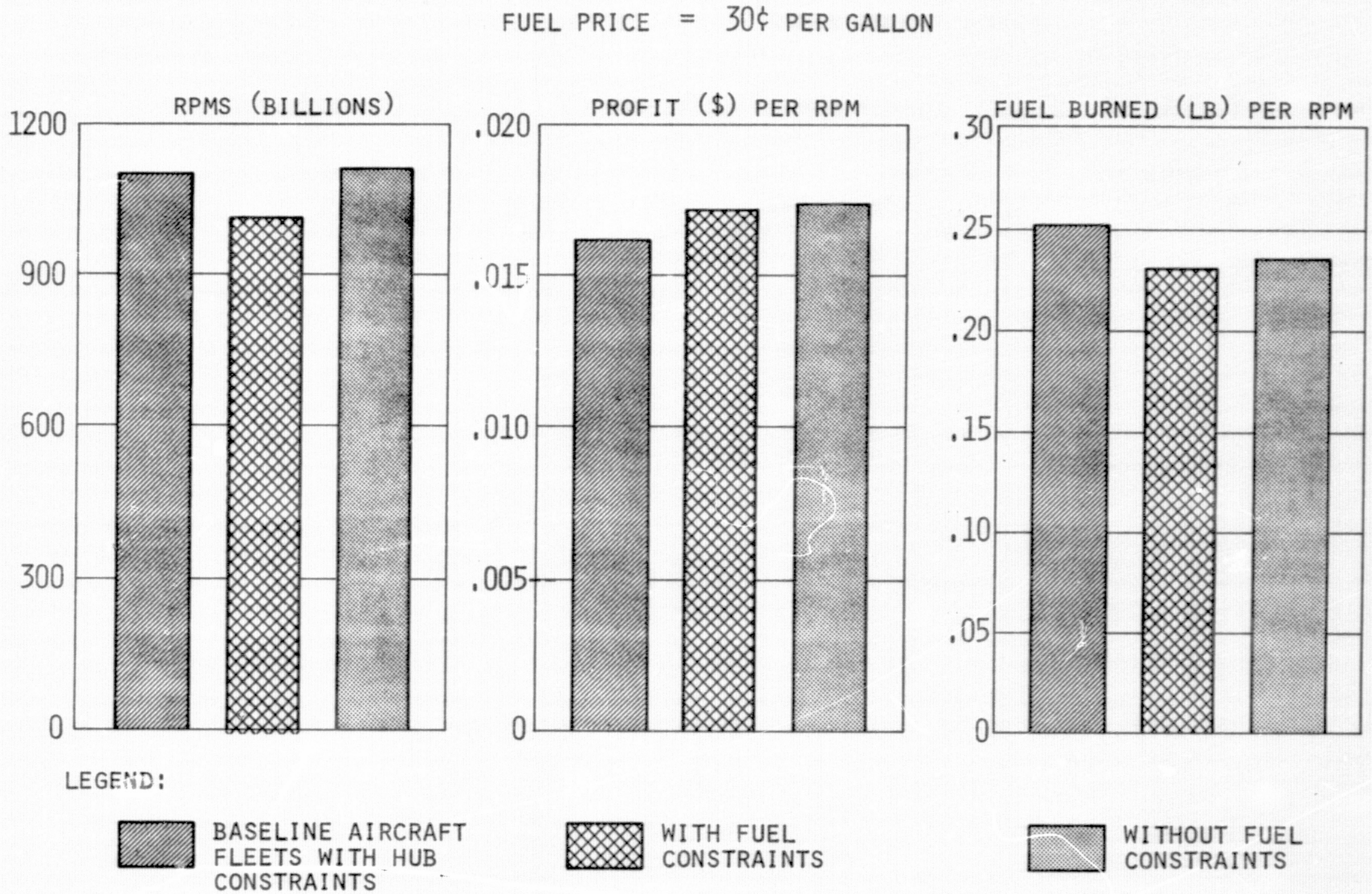


Figure 61. Fleet Forecast Results With Selected Mods, Derivative, and New Near-Term Aircraft

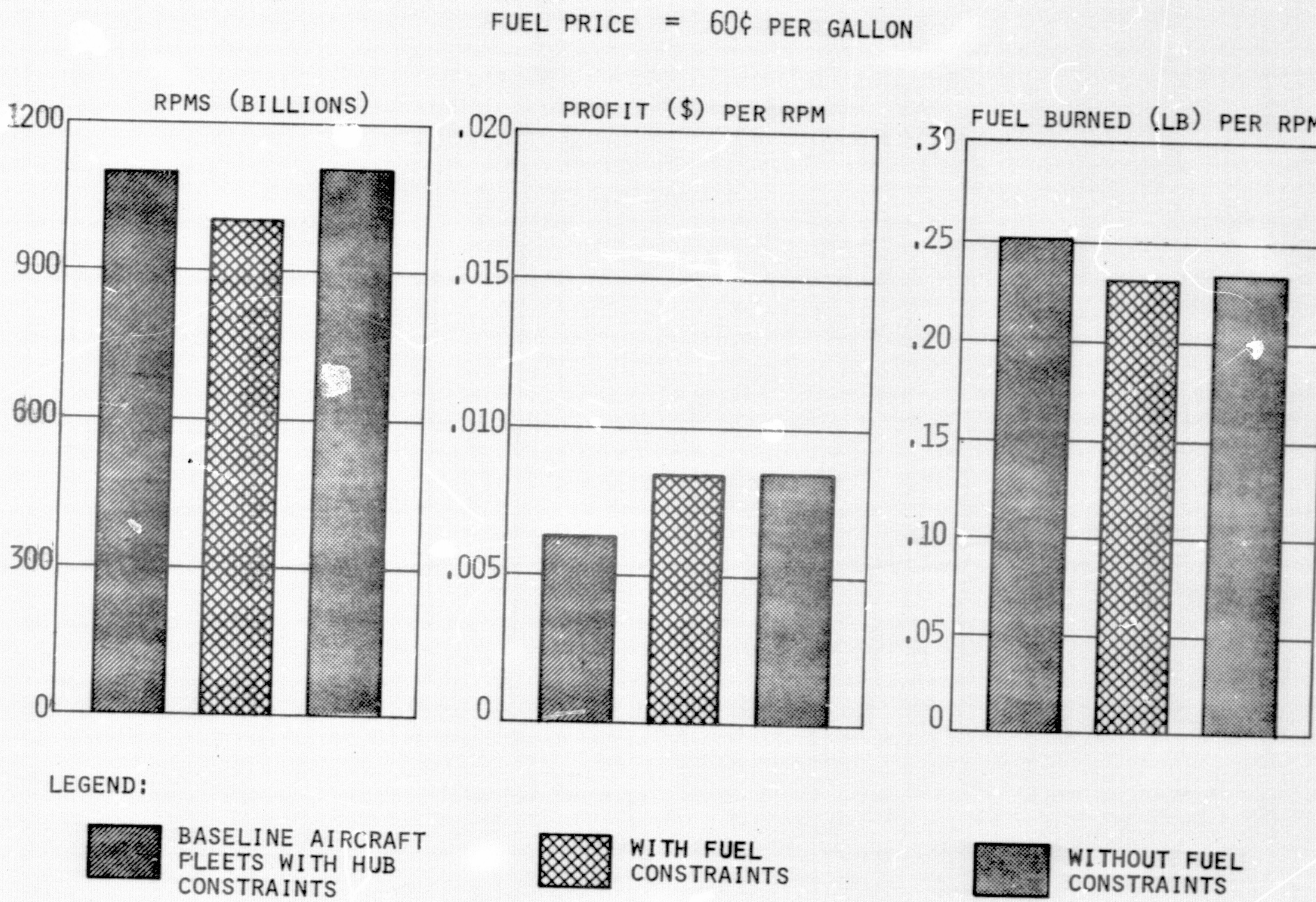


Figure 62. Fleet Forecast Results With Selected Mods, Derivatives, and New Near-Term Aircraft

7 and 8 percent over the study period. Although the N80 airplanes were made available in 1980, the market did not start to require a sizeable number of them until 1984-1985. The N80-2.15$_{30}$ was an exception to this, and a sufficient quantity of airplanes was desired by the market as soon as it became available. Fuel savings for the period 1980-1990 for the selected fleets with the N80's varied from 10 percent to almost 13 percent as shown in Table 59.

Load Factor Variations - Using the operating environment and the offering of aircraft options for the selected N80 scenario with unconstrained fuel at 30 cents per gallon, two additional scenarios were developed to investigate the effects of load factor variations. The study goal load factor was 58 percent. This goal load factor was decreased to 55 percent in one scenario and increased to 70 percent in the other. These results were compared with the results of the selected N80 scenario, as well as the hub-constrained reference case and the baseline scenario, all with fuel at 30 cents per gallon and a goal load factor of 58 percent. The fleet forecast results are shown in Figures 63 and 64.

In measuring the impact of load factor, the results were compared directly with those for the selected N80 scenario. At a 55 percent load factor, RPM's were 1 percent less, but with a 70 percent load factor, revenue passenger-miles increased by 1.4 percent over the selected N80 scenario with a 58 percent load factor during the forecast period. Profit per RPM from 1973-1990 with a 55 percent load factor was over 6 percent less, while at 70 percent it was almost 16 percent higher. Fuel burned per RPM increased by 3 percent with a 55 percent load factor, but decreased during the study period by almost 7 percent for a 70 percent load factor. From 1980-1990 fuel burned per RPM increased by almost 4 percent at a 55 percent load factor but decreased by over 10 percent at 70 percent, demonstrating the strong impact load factor alone has on fuel conservation.

Traffic Demand Variations - Eight operating scenarios were developed to investigate the effect varying traffic demand would have on fuel savings and profit generated. Four scenarios were studied under an unlimited fuel environment, and the other four were considered in a fuel-constrained environment.

TABLE 59

COMPARATIVE FLEET FORECAST RESULTS FOR SELECTED AIRCRAFT OPTIONS

STUDY SCENARIOS	RPM'S (Billions)		ANNUAL FLEET SIZE (Number of Airplanes)				FUEL SAVINGS (Percent)	
	1973-1990	1980-1990	1973	1980	1985	1990	1973-1990	1980-1990
BASELINE SCENARIOS								
Hub-Constrained @ 30¢	1105.469	763.816	559	594	647	718	-	-
Hub-Constrained @ 60¢	1103.723	762.065	559	594	645	717	-	-
AIRCRAFT OPTION SCENARIOS								
Constrained Fuel								
Retrofits @ 30¢	988.499	652.357	559	566	577	580	3.2	5.4
Mods + Derivs. @ 30¢	990.821	657.690	559	575	590	594	4.5	7.3
Mods & Derivs. + N80s @ 30¢	1015.761	682.630	559	572	579	581	8.1	12.5
Mods & Derivs. + N80s @ 60¢	1002.882	669.889	559	550	568	573	8.1	12.6
Unlimited Fuel								
Retrofits @ 30¢	1105.091	764.051	559	590	643	714	1.4	2.0
Mods + Derivs @ 30¢	1115.868	774.263	559	598	642	727	4.7	7.0
Mods & Derivs. + N80s @ 30¢	1116.354	774.749	559	592	637	716	6.8	10.2
Mods & Derivs. + N80s @ 60¢	1109.657	769.789	559	589	634	710	7.6	11.1

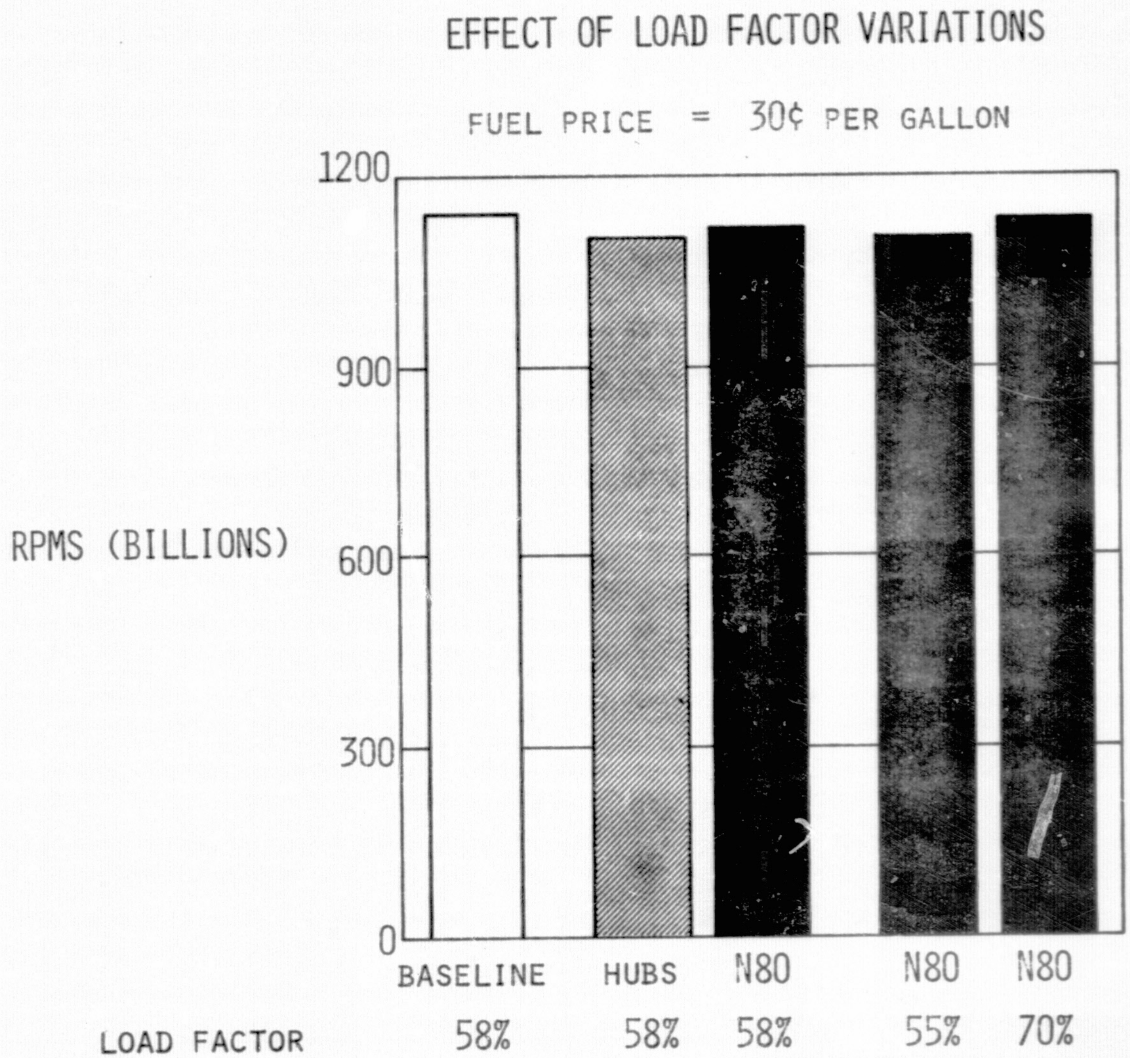


Figure 63. Fleet Forecast Results With Selected Mods, Derivatives, and New Near-Term Aircraft

EFFECT OF LOAD FACTOR VARIATIONS ON PROFIT AND FUEL SAVINGS

FUEL PRICE = 30¢ PER GALLON

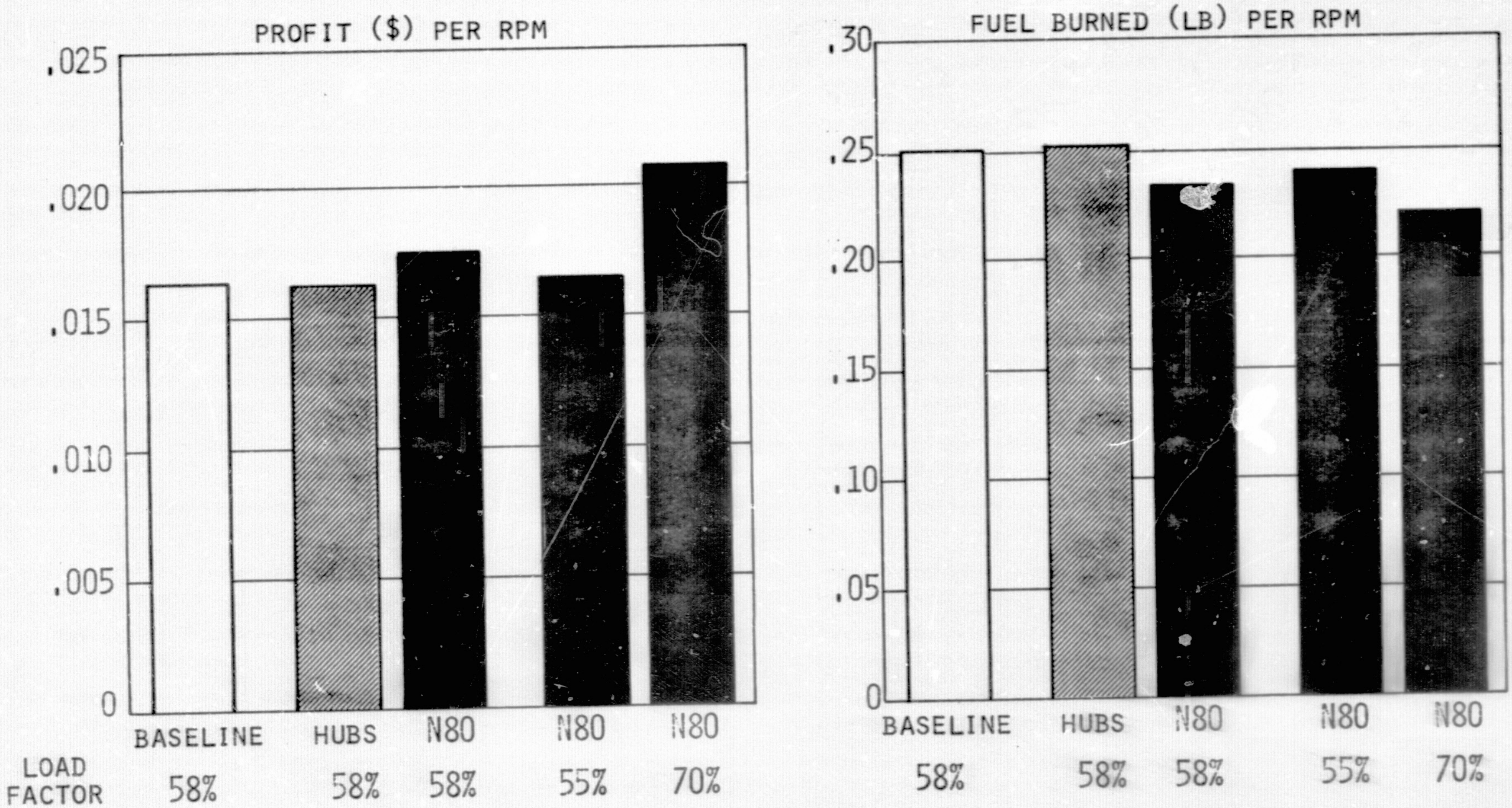


Figure 64. Fleet Forecast Results With Selected Mods, Derivatives, and New Near-Term Aircraft

Under each fuel environment, RPM's were increased and decreased by 10 percent at fuel prices of 30 cents and 60 cents per gallon. Otherwise all the scenarios represented the operating environment and the offering of aircraft options of their respective N80 scenarios.

From this preliminary analysis, it was apparent that fuel savings of between 3-4 percent per RPM could be realized with a 10 percent increase in RPM demand over the forecast period. These savings were virtually the same under both fuel environments and both fuel prices of 30 and 60 cents per gallon. On the other hand, when RPM demand was reduced by 10 percent, the fuel burned per RPM by the forecasted fleets over the same period increased by 3-4 percent regardless of fuel environment or fuel price. With increased RPM demand, larger more fuel efficient aircraft were able to satisfy the minimum frequency requirements that had previously precluded their profitability on certain low traffic routes. Conversely, with decreased RPM demand, the aircraft previously selected as satisfactory could no longer profitably meet the minimum frequency levels and were replaced by smaller less fuel efficient types.

Fare Variations - A preliminary analysis was also made of the effect differing traffic demands would have on the required fare levels. This analysis was carried out to provide equivalent airline profits (profit per RPM) in each scenario regardless of the level of traffic demand. It was not the intention of this study to attempt to readjust the CAB's Phase IX fare levels at each stage length. Therefore, the initial results given here were based on the assumption that fare increases or decreases would be carried out uniformly across all stage lengths, and RPM demand variations were also applied to each city pair in the study market.

From this analysis, it appears that in both fuel environments with a fuel price of 30 cents per gallon, a 10 percent increase in RPM demand would allow a 5 percent reduction in fares to achieve the same profit per RPM as the N80 scenarios with the baseline traffic demand. A 10 percent decrease in RPM's would require a 5 percent increase in fares to achieve the same profit level as the baseline N80 cases.

With a fuel price of 60 cents per gallon and either fuel environment, a 10 percent increase in traffic demand would allow approximately a 12-13 percent decrease in fare levels while a decrease in RPM demand of 10 percent would require a 15-20 percent increase in fares to achieve the same profit per RPM as the baseline N80 cases. Again the percentage increase or decrease in profit per RPM is greater with a fuel price of 60 cents per gallon than with fuel at 30 cents per gallon. Therefore, the fleet forecast results are good only for comparison with other 60 cents per gallon fuel scenarios.

Although the assumptions used in this preliminary fare analysis would not be totally valid in the real airline world, they were adequate to provide "ball-park" results for the purpose of this study. Obviously, an in-depth study of traffic demand and fare levels and their interreactions, as well as the effects of other airline operating factors, would be necessary to more accurately predict the impact of traffic demand and fuel price on fares. This study would most certainly have to include an assessment of the future elasticity of air travel demand in the U.S. domestic air transportation system.

3.8 Summary of Results and Conclusions

3.8.1 Revenue Passenger-Miles

The RPM's flown from 1973-1990 over the study network varied under each operating scenario. Upon implementation of the hub constraints, no scenario in either fuel environment carried all the forecasted RPM demand. In an unlimited and limited fuel environment with hub constraints, the baseline fleet performed 96.5 percent and 82 percent respectively of the total fore-casted RPM demand during 1973-1990. However, when the derivative and N80 aircraft options were added into the fleets, 97-98 percent of the RPM's were performed in the unconstrained fuel scenarios, but only 87-89 percent of the RPM's were carried in the fuel constrained scenarios during the study period. With fuel constraints, the operating scenarios satisfied only 71-75 percent of the demand in 1990, while in the unconstrained fuel scenarios, only 5 per-cent of the RPM's were not carried in 1990. The revenue passenger-miles generated over the DC-Jet route network under each fuel environment were then projected to the total U.S. domestic system as shown in Table 60.

TABLE 60

PROJECTION OF U.S. DOMESTIC SYSTEM RPM's
(1973-1990)

	DC-Jet Network	U.S. Domestic System
Without Fuel Constraints	1105 - 1144 Billion	Approx. 3300 Billion
With Fuel Constraints	990 - 1015 Billion	Approx. 2950 Billion

3.8.2 Fleet Sizes

The fleet sizes predicted for 1990 on the DC-Jet Network were obviously dependent on the fuel environment. With the implementation of fuel constraints, the fleet size required was considerably smaller due to the lack of ability to perform all the RPM demand within the allocated fuel levels.

The actual fleet sizes required by operating scenario and fuel environment from 1973-1990 are depicted in Figures 65-66. Although each year from 1973-1990 was considered in each fleet forecast, for presentation purposes the fleet sizes for just the selected years are shown. Table 61 compares the average fleet sizes needed in 1990 for the DC-Jet Network with and without fuel constraints. Using these average fleet sizes, the number of aircraft needed for the total U.S. domestic system in 1990 were estimated and are also given in Table 61. The estimated fleet size for the U.S. domestic system with no fuel constraints correlates well with other recent studies predicting fleet sizes of approximately 2100 airplanes in 1990.

TABLE 61

1990 FLEET SIZES

	DC-Jet Network	U.S. Domestic System
Without Fuel Constraints	700 - 725	2050 - 2150
With Fuel Constraints	575 - 600	1700 - 1800

3.8.3 Selected Aircraft Options

The types and numbers of each aircraft required in each scenario varied, but certain aircraft options were selected in sufficient quantity by the market in almost every scenario, and these are listed in Table 62. Out of the 32 aircraft options studied, 10 were selected as the most promising for fuel conservation as well as being economically and operationally viable under the two fuel environments examined.

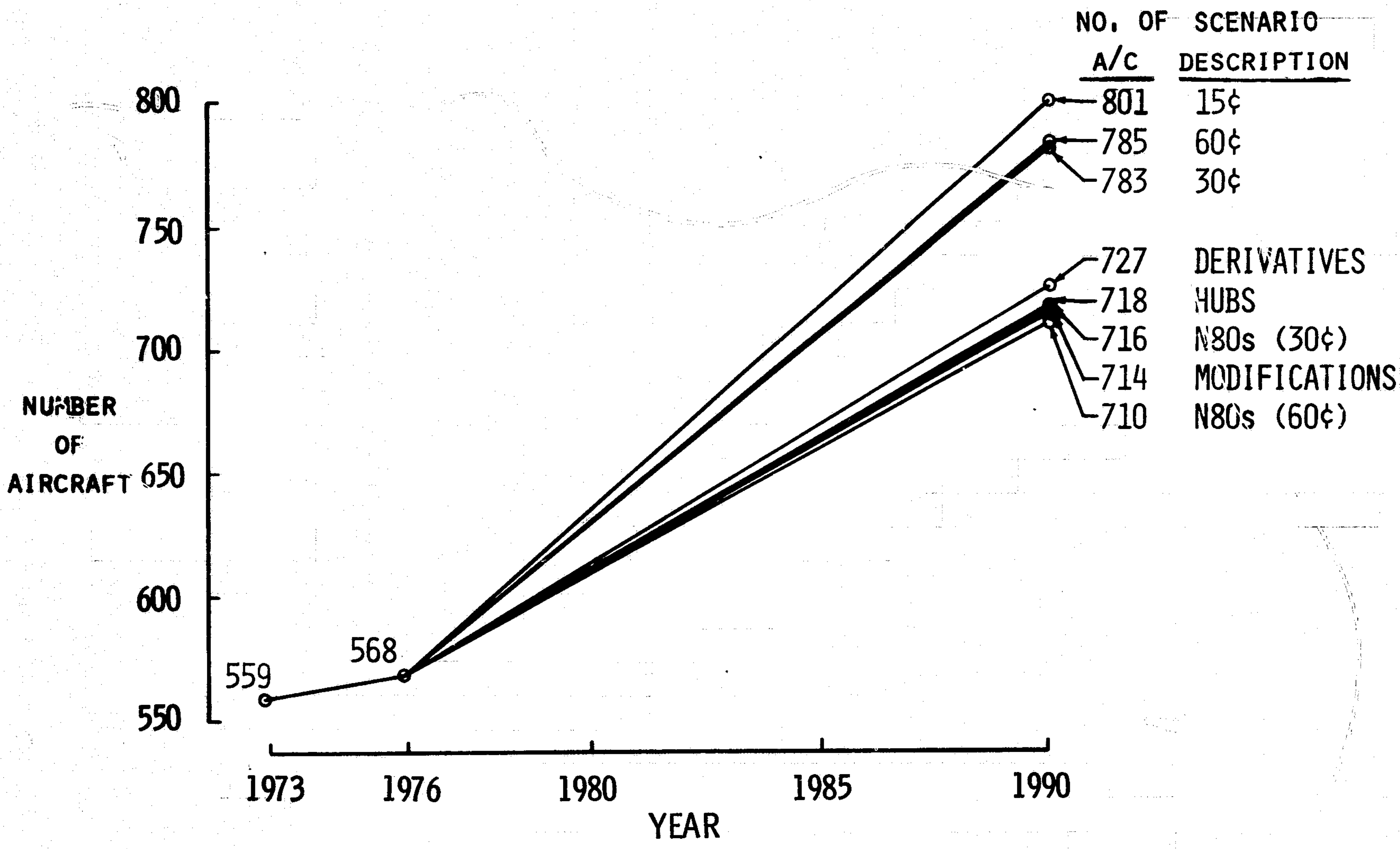


FIGURE 65. FLEET SIZES BY YEAR - UNCONSTRAINED FUEL ENVIRONMENT

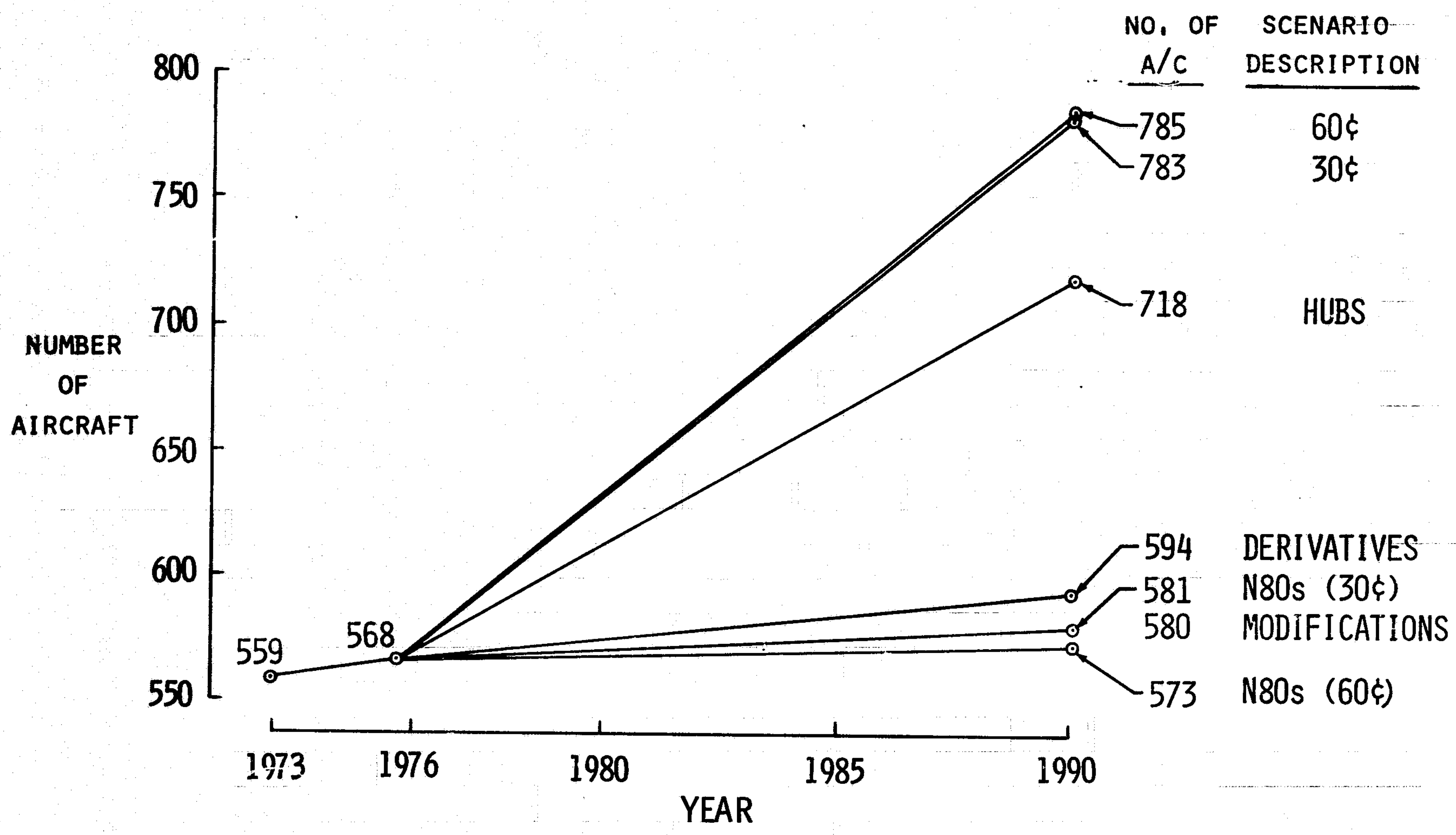


FIGURE 66. FLEET SIZES BY YEAR - CONSTRAINED FUEL ENVIRONMENT

TABLE 62

MOST PROMISING AIRCRAFT OPTIONS FOR REDUCING FUEL CONSUMPTION

Number of Study Options	Selected Aircraft Options: With Fuel Constraints	Selected Aircraft Options: Without Fuel Constraints
13 Retrofits	DC-8-50 DR DC-8-61 DR DC-10-10 R	DC-8-50 DR DC-8-61 DR
7 Derivatives	DC-9-30 D3 DC-10-10 D	DC-9-30 D1 DC-9-30 D3 DC-10-10 D
12 New Near-Term	N80-2.15$_{30}$ N80-2.30$_{30}$ N80-4.30$_{30}$ N80-4.30$_{60}$	N80-2.15$_{30}$ N80-4.30$_{30}$ N80-4.30$_{60}$

The potential U.S. market requirement for each selected aircraft option was projected and is given in Table 63. For the selected retrofit aircraft options, the total potential program size was equal to the numbers of existing aircraft of that type available for retrofitting in the U.S. airline fleets.

TABLE 63

PROJECTED POTENTIAL MARKET SIZES
(1990)

Selected Aircraft Options		Potential U.S. Domestic Aircraft Market
Derivatives		
DC-9-30D1		500 - 550
DC-9-30D3		175
DC-10-10D		90
New Near-Term Aircraft		
N80-2.15$_{30}$		60
N80-2.30$_{30}$	(Fuel Constrained Environment Only)	45
N80-4.30$_{30}$		150
N80-4.30$_{60}$		120

Market sizes for the derivative options were rewarding, especially in terms of the fuel savings potential they offer, as well as the economic viability they would provide the manufacturer. It should be pointed out that the market sizes estimated in this study did not include the potential for further aircraft sales for use in the fleets of the foreign carriers. This additional aircraft demand would certainly induce a manufacturer to produce one or more of the selected derivative options.

The market requirements for the N80 airplanes were too low to establish a viable new aircraft program. However, it should be remembered that the majority of the selected N80 options were not needed by the market until 1984-1985, and therefore, a market size determined in 1990 is somewhat premature. This points to the desireability of delaying introduction of the N80's until 1985-1990, and that the year 2000 would be more appropriate to use in determining market sizes for these options.

If the market demands for the N80-4.30_{30} and N80-4.30_{60} airplanes could be combined, this would provide a reasonable aircraft breakeven quantity for a manufacturer interested in producing an airplane in this size and range class. Due to the very small differences between models in operating costs and aircraft price, an optimized design based on these two airplanes for a fuel price actually appropriate at the time of aircraft operation might be the best new fuel conservative airplane option to develop.

The market size for the N80-2.15_{30} was not as large as anticipated due to the competition from the 117 seat derivative DC-9, designated the DC-9-30 D1. This airplane option was better sized for the market growth forecasted in this study. For this reason, as well as the large number of short haul airline routes domestically, it would be worthwhile to study a fuel conservative 125-150 seat, 1500 nautical mile range N80 aircraft in the U.S. domestic system. This airplane might prove to be highly viable in the market by replacing older DC-9/B737/B727 aircraft types and producing significant fuel savings within the system. Otherwise, in order to maximize fuel savings in the near-term, the air transportation industry should concentrate on the derivative options while continuing to research the technology necessary for developing promising new aircraft designs for a 1985-1990 introduction date.

3.8.4 Fuel Consumption and Savings

Based on the fleet forecast results discussed in the preceding paragraphs (Sections 3.8.1, 3.8.2, and 3.8.3), the potential fuel savings of these results over the DC-Jet route network can be documented. As expected, the baseline scenario with fuel at 15 cents per gallon demanded the most jet fuel, 144.5 million tons, over the forecast period, 1973-1990. The lowest fuel consumption at both study fuel prices was achieved by the mixed fleet of selected retrofits, derivatives, and new near-term aircraft performing the same or more RPM's than the baseline scenarios with hub constraints, 131.3 million tons and 129.3 million tons at fuel prices of 30 cents and 60 cents per gallon, respectively.

The fuel consumed by the fleet forecasted for each scenario is given in Table 64. For comparison purposes, four time periods are shown: annually for 1980 and 1990, as well as cumulatively for 1973-1990 and 1980-1990. The cumulative time period, 1980-1990, was included since the majority of the aircraft options were introduced to the market in 1980. The fuel savings over this period more realistically represent the actual fuel savings that could be achieved through the use of the selected study options. Figures 67 and 68 graphically depict, by year, the cumulative fuel consumptions for each fleet forecast under the two fuel environments.

The potential for fuel savings with each succeeding fleet forecast based upon different offerings of aircraft options under both fuel environments is shown in Table 65. The fuel consumed in the various fleet forecasts over the forecast period and the 1980-1990 time period, as well as in the year 1990 were compared for efficiency on the basis of pounds of fuel burned per RPM, since the RPM's for each scenario were different. The results of the 30 cents scenario were judged against those of the hub-constrained scenario with fuel at 30 cents per gallon, and the results of the 60 cents scenarios were compared against those for the 60 cents scenario with hub constraints.

From Table 65, it can be seen that fuel conserving operating procedures offered as much as a five percent reduction in fuel burned over the study period, and over 6 1/2 percent in 1990 alone. Assuming an improved ATC system became operational in 1980, the fuel savings attributable to this improvement alone

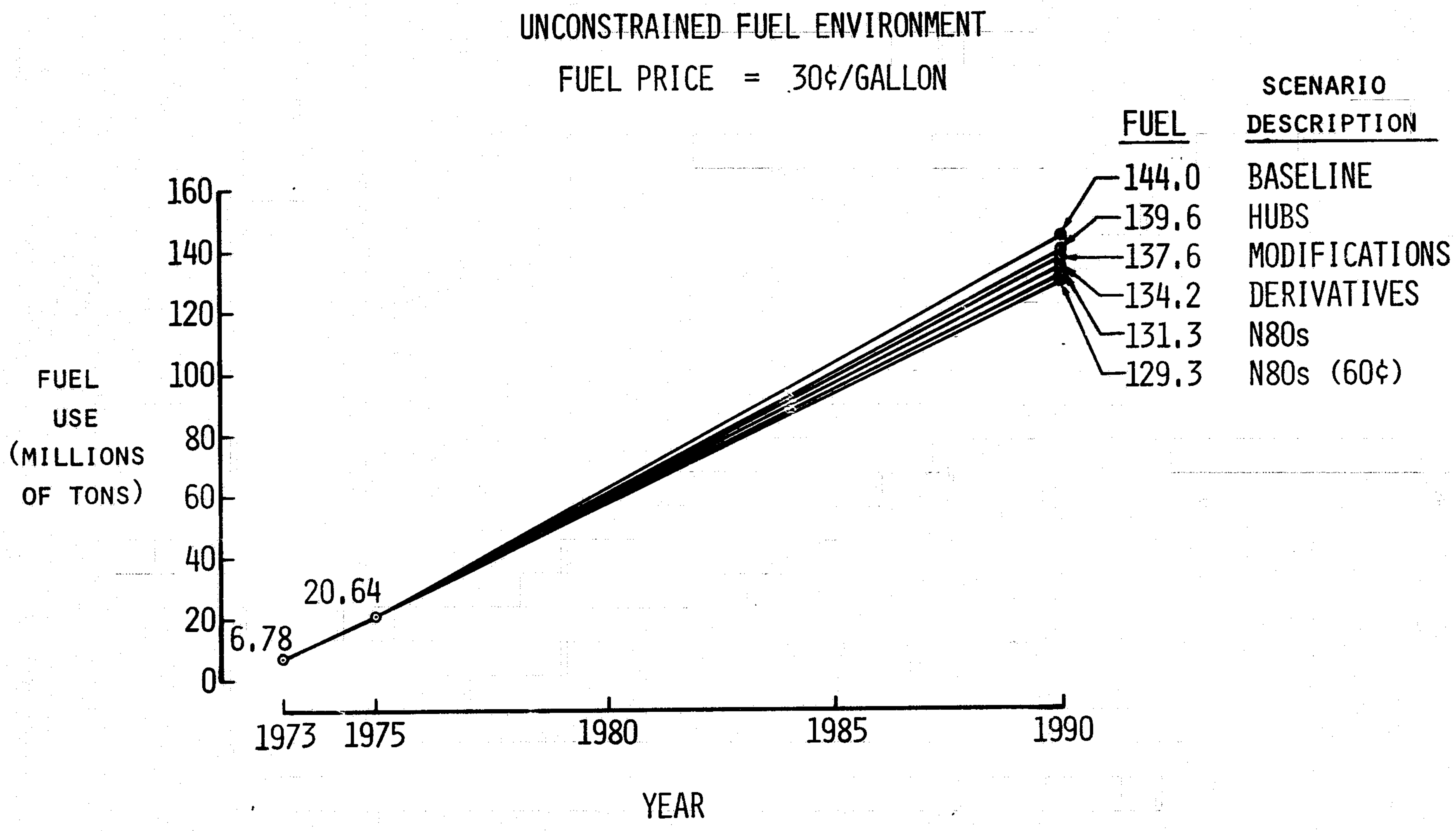


FIGURE 67. COMPARATIVE CUMULATIVE FUEL DEMAND (1973-1990)

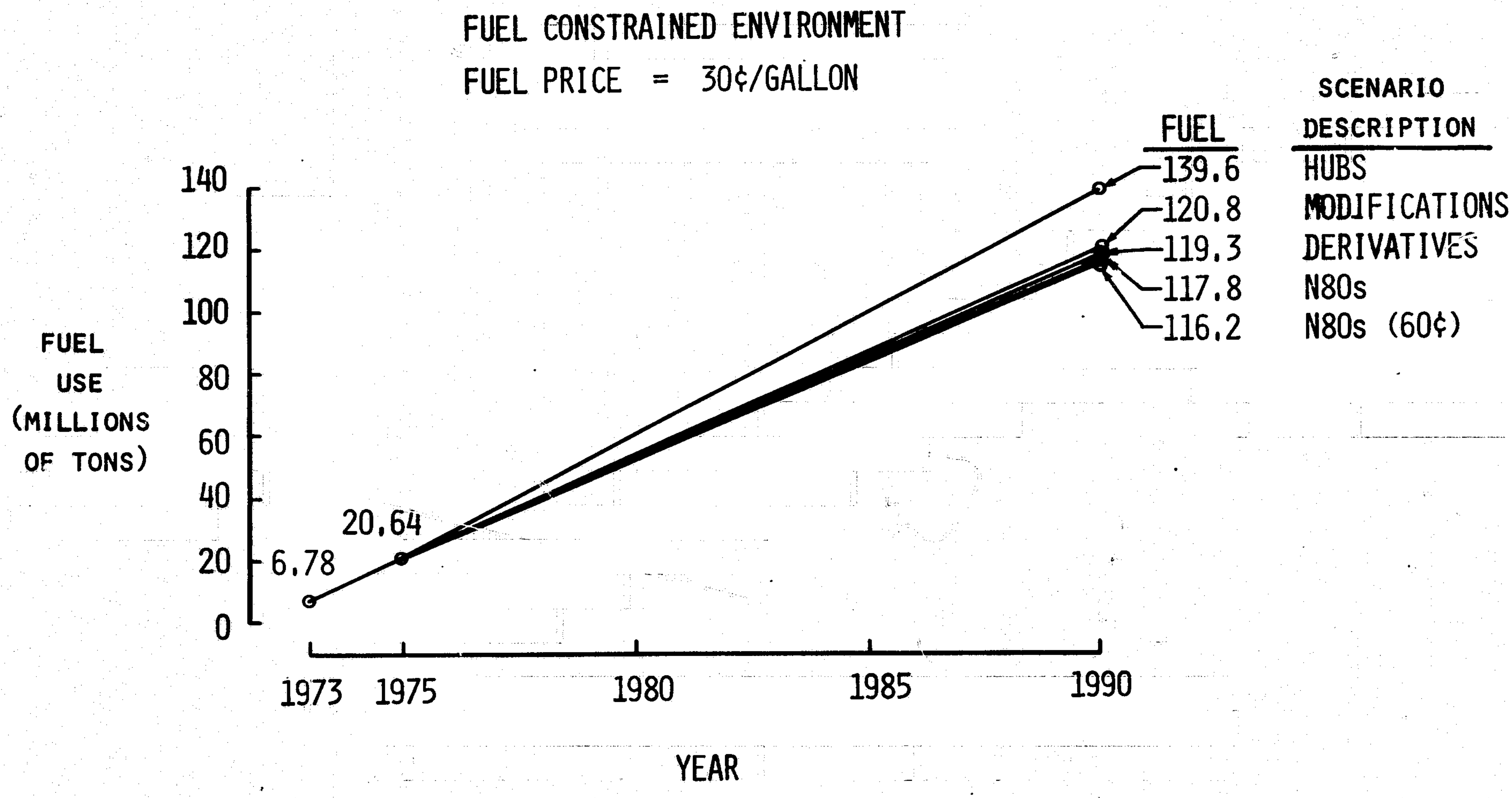


FIGURE 68. COMPARATIVE CUMULATIVE FUEL DEMAND (1973-1990)

TABLE 64

COMPARATIVE FUEL BURNED (MILLIONS OF TONS)
TOTAL DC-JET ROUTE NETWORK

Scenario Description & Fuel Price (¢/Gal)	Annual		Cumulative	
	1980	1990	1980-1990	1973-1990
BASELINE SCENARIOS				
15¢	7.229	10.130	95.494	144.457
30¢	7.229	10.068	95.124	144.076
60¢	7.229	10.061	94.974	143.979
HUBS @ 30¢	7.158	9.280	90.948	139.592
HUBS @ 60¢	7.158	9.169	90.550	139.120
Fuel Constrained @ 30¢	6.770	6.776	74.507	122.181
Consv. Flt. Opers. @ 60¢	6.708	8.541	84.720	132.088
Consv. Flt. Opers. + 1980 ATC @ 60¢	6.432	8.200	81.410	128.530
UNLIMITED FUEL SCENARIOS				
Modifications @ 30¢	6.888	9.144	89.188	137.552
Derivatives* @ 30¢	6.935	8.805	85.741	134.231
N80s** @ 30¢	6.749	8.365	82.844	131.341
N80s** @ 60¢	6.599	8.199	81.291	129.312
N80s** - 55% L.F. @ 30¢	6.955	8.668	85.006	133.637
N80s** - 70% L.F. @ 30¢	6.749	7.380	75.909	124.406
CONSTRAINED FUEL SCENARIOS				
Modifications @ 30¢	6.455	6.756	73.514	120.795
Derivatives* @ 30¢	6.452	6.679	72.597	119.323
N80s** @ 30¢	6.312	6.550	71.103	117.829
N80s** @ 60¢	6.026	6.528	69.611	116.223

*Derivatives = Modifications + Derivatives
**N80s = Modifications + Derivatives + N80s

NOTE: Fuel burned on DC-Jet network in 1973 = 6.784 million tons

TABLE 65

COMPARATIVE FUEL SAVINGS PER RPM (PERCENT)
TOTAL DC-JET ROUTE NETWORK

Scenario Description & Fuel Price (¢/Gal)	Cumulative		Annual
	1973-1990	1980-1990	1990
Relative to hub-constrained scenarios @ 30¢ and 60¢ per gallon			
BASELINE SCENARIOS			
Fuel Constrained @ 30¢	-2.9	-6.0	-6.2
Consv. Flt. Opers. @ 60¢	4.9	6.3	6.6
Consv. Flt. Opers. + 1980 ATC @ 60¢	7.5	10.1	10.5
UNLIMITED FUEL SCENARIOS			
Modifications @ 30¢	1.4	2.0	1.4
Derivatives* @ 30¢	4.7	7.0	8.3
N80s** @ 30¢	6.8	10.2	13.4
N80s** @ 60¢	7.6	11.1	14.8
N80s** - 55% L.F. @ 30¢	4.3	6.8	9.5
N80s** - 70% L.F. @ 30¢	13.0	19.3	26.2
CONSTRAINED FUEL SCENARIOS			
Modifications @ 30¢	3.2	5.4	3.6
Derivatives* @ 30¢	4.5	7.3	6.3
N80s** @ 30¢	8.1	12.5	15.6
N80s** @ 60¢	8.1	12.6	14.3
Relative to baseline fuel constrained scenario @ 30¢ per gallon			
CONSTRAINED FUEL SCENARIOS			
Modifications @ 30¢	5.9	8.5	9.2
Derivatives* @ 30¢	7.3	10.3	11.8
N80s** @ 30¢	10.7	15.4	20.5

*Derivatives = Modifications + Derivatives
**N80s = Modifications + Derivatives + N80s

equalled almost 4 percent in 1990 as well as over the period 1980-1990. The total potential fuel savings from fuel conserving operational procedures and an advanced ATC were over 10 percent in the same time periods. These savings equate to over 9 million tons during 1980-1990 and almost a million tons in the year 1990 alone.

The three most promising modifications options selected by the market in this study saved almost 1 1/2 percent fuel during 1973-1990, 2 percent during 1980-1990 and less than 1 1/2 percent in 1990. Since the number of retrofit options available to the market was discrete, the savings did not change significantly during any time period. However, when the selected derivative options were added to the fleet of existing airplanes and selected mod options, fuel savings improved substantially to 7 percent during 1980-1990 and almost 8 1/2 percent in 1990 alone, or a savings of over 5 million tons from 1980-1990.

Fuel savings continued to improve with the addition of each group of selected options: the modification options alone, the mods plus derivatives, and then the mods, derivatives, and N80's, as can be seen in Table 65. The highest fuel savings were achieved with a mixed fleet of aircraft options (mods, derivatives, plus N80's) selected for a fuel price of 60 cents per gallon. This fleet reduced jet fuel consumption by almost 8 percent over the total forecast period, over 11 percent during 1980-1990, and by nearly 15 percent in the year 1990 alone. These fuel savings produced by the mixed fleet of selected aircraft options amounted to 400 million gallons in the year 1990 alone and over 3 billion gallons from 1973-1990 when compared with the baseline hub-constrained fleet forecast for a fuel price of 60 cents per gallon. Fuel savings achieved with the mixed fleet selected by the market when fuel was 30 cents per gallon were approximately one percent less in each of the time periods than they were with the fleet selected for fuel at 60 cents.

When the goal load factor was increased from 58 percent to 70 percent in 1980, the fuel savings achieved with a market selected fleet (mods, derivatives, plus N80's) of the aircraft options, at a fuel price of 30 cents per gallon were significant. Fuel savings of 9 percent during 1980-1990 and 13 percent during 1990 alone were produced above those savings already provided by the mixed fleet selected at the same fuel price but with the study load factor of 58 percent.

Results for the comparable fleet forecasts under a fuel allocated environment were very similar, although the fuel savings in percentages were generally higher as shown in Table 65. In the fuel constrained scenarios, the market selected those aircraft types which maximized profits, within the total fuel allocation. Thus, these fleets tended to perform the greatest number of RPM's per pound of fuel. When fuel savings achieved with the unlimited fuel fleets were compared with those for the fuel constrained fleets, this higher fuel efficiency generally resulted in higher percentage fuel savings.

3.8.5 Study Conclusions

The most important conclusions that can be drawn about the relative importance of each of the fuel saving options in reducing the fuel consumption of the U.S. domestic air transportation system during 1973-1990 are:

- o Fuel conserving flight procedures offer important immediate fuel savings, many of which have already been implemented.
- o Additional fuel savings could be obtained operationally with an improved ATC system.
- o Higher load factors would improve fuel efficiency substantially in a static airline environment.
- o Aerodynamic retrofits appear to be worth pursuing in terms of fuel savings and modest economic gains for a short interim period.
- o Reengining older narrow body aircraft for saving fuel is too expensive to be a viable fuel conserving alternative.
- o Derivatives of current airplanes, sized to meet the future needs of the market, would offer significant fuel savings as well as improved economics over the modification of current aircraft. Certain derivatives could also offer other environmental advantages to the air transportation system such as the reduction of noise and pollution compared with the modification options.
- o The derivative aircraft were the most promising options in terms of fuel conservation as well as economic viability for the near term, since market introduction of the N80's was too close to that for the derivatives to provide substantial additional fuel savings during that time period.
- o However, the all-new (N80) aircraft offer the greatest potential for fuel savings and improved economics in the far term, beyond 1985-1990.

SECTION 4.0

U.S. INTERNATIONAL MARKET

The international market operated by the U.S. scheduled airlines was also studied in order to determine the anticipated fuel demand and fleet requirements for these carriers during the period 1974-1990. Several possible long-range derivatives of existing aircraft as well as six all-new near-term aircraft (N80's) were analyzed in terms of their economic viability and potential fuel savings relative to the baseline 1974 airplanes already in the airline fleets. In accomplishing this task, alternative fleet forecasts were developed to screen these possible aircraft options against the U.S. international market requirements. The results of the forecasts were then compared both economically and operationally. As in the domestic study, the criteria used in comparing viability included operating costs, potential airline profit, revenue passenger-miles flown, fuel saved and forecasted fleet size and mix.

4.1 STUDY APPROACH

The U.S. international scheduled market and its characteristics were carefully reviewed, and a forecast was made of the potential traffic demand in this market from 1974-1990 using the actual revenue passenger-miles for the 1974 base year. A baseline operational scenario was developed to reflect the operating environment of the U.S. international carriers during 1974. Next, several operational conditions or constraints in this baseline scenario were varied in order to determine the impact of these constraints on fuel burned and saved, profit generated, as well as fleet size and mix. The constraints that were varied included fuel price, goal load factor, fuel availability, as well as the grouping of aircraft options offered to the market.

A Douglas computer program, the Performance Evaluation Technique, was used to determine the alternative fleet forecasts for each scenario. The objective criterion was to maximize airline profits through the appropriate choice of offered aircraft options under a particular operating environment. Using this method the operational and economic performances of the existing, derivative, and new near-term aircraft options were measured in the simulated airline operational scenarios. Further discussion of this computer program can be found in Section 1.9, page 20.

4.2 STUDY MARKET CHARACTERISTICS

The markets served by the U.S. international scheduled carriers were developed from the August 1974 Official Airline Guide. August was chosen since this month represented the peak month of the year for passenger traffic. Data was collected for each city pair and included the available seat-miles, departures, and aircraft types. Based upon the CAB's Uniform Systems of Accounts - Part 241, the U.S. international market excludes operations to Hawaii and Alaska as well as all Canadian transborder services.

4.2.1 Available Seat-Miles

The available seat-miles determined for this market during August 1974 were adjusted to an annual basis using the CAB's Seasonally Adjusted Data Report for the scheduled international trunks. The August ASM's represented 9.6 percent of the annual 1974 available seat-miles. Therefore, the U.S. international scheduled carriers generated over 63 billion ASM's in 1974. This total was verified by annual data reported by the airlines and published by the CAB. The actual 1974 available seat-miles were adjusted by aircraft type to reflect the average seating density for that aircraft type in U.S. international service. The average number of seats for each aircraft in 1974 were determined from the CAB data published on the international carriers in the Aircraft Operating Cost and Performance Report, July 1975.

Use of the average aircraft seating configurations increased the 1974 ASM's to 65 billion and decreased the actual 1974 load factor of 53 percent to 51.4 percent. The effect of this decision was to dampen the ASM growth for the first several years of the forecast reflecting few new purchases of aircraft. In reality, the U.S. international airlines did not acquire much new equipment during 1975-1976. This decision also delayed the attainment of the goal load factor until 1980. A planning or goal load factor of 58 percent had been established based on Douglas estimates of an average load factor for the U.S. international scheduled carriers during the 1976-1990 study period. The actual available seat-miles generated during the forecast period varied for each operating scenario and fleet studied.

4.2.2 Revenue Passenger-Miles

The RPM demand of 33.4 billion in 1974 was determined using the actual load factor of 53 percent applied to the actual 1974 ASM's. Then the revenue passenger-miles were forecast from 1974 to 1990 using an average annual growth rate of 4.6 percent. This growth rate represents Douglas' estimate of a realistic average over this period for the U.S. international scheduled carriers. Using this growth rate, the U.S. international RPM's grew from 33.4 billion in 1974 to almost 69 billion by 1990, a 100 percent increase over the period (Figure 69).

4.2.3 Stage Length Classes

The market's operating statistics had to be condensed in order to facilitate computer computation of a large amount of data. Stage length classes were established that consolidated similar daily operational statistics by airport pairs and aircraft types into compatible groups. In selecting appropriate stage length classes, the distribution of the 1974 available seat-miles and departures with range were compared as illustrated in Figure 70.

Over 50 percent of the departures were on routes under 900 miles while only 9 percent of the ASM's were generated on these routes. The B727-100 fleet had the greatest number of departures per airplane type in this market during 1974 with an average stage length of 387 statute miles. On the other hand almost 57 percent of the ASM's were produced on routes longer than 3000 miles but with only 16 percent of the departures. As expected, the ASM's were heavily concentrated at the longer stage lengths since seat-miles are a direct function of the flight mileage and the number of seats. The larger aircraft types, namely the B747, were used primarily in the longer haul markets. The B747 fleet's average stage length in 1974 was 2324 statute miles.

Therefore, as in the domestic market, the distribution of the departures as a function of range became the primary determinant in establishing the stage length classes. This selection was made in order to preserve the importance of the short to medium haul markets in the data. Table 66 shows the classes chosen and the percentage of departures and available seat-miles per class. The greatest mileage spread within a class was at the longer ranges.

AVERAGE ANNUAL GROWTH RATE (1974-1990) — 4.6 PERCENT

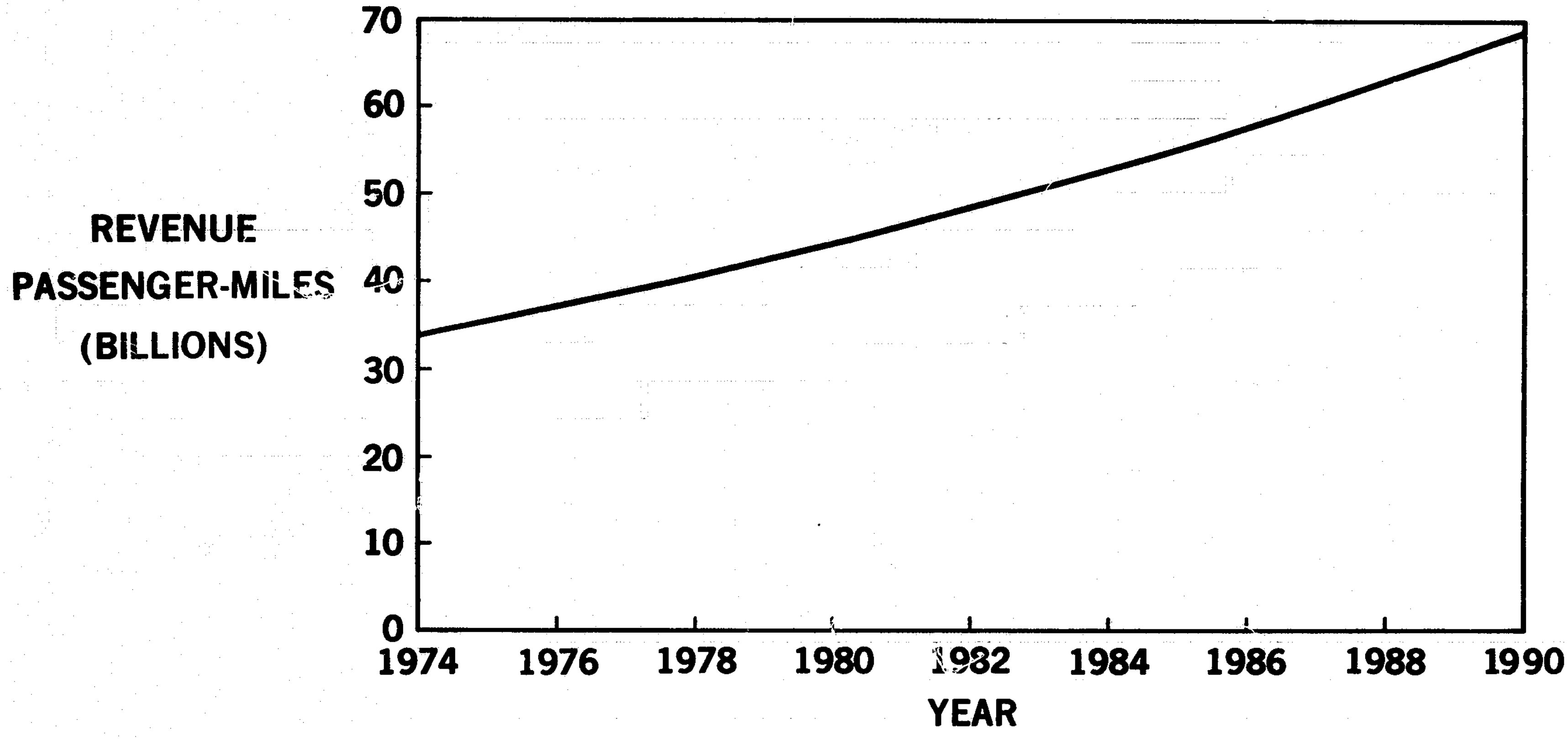


FIGURE 69. U.S. SCHEDULED INTERNATIONAL REVENUE PASSENGER-MILE FORECAST

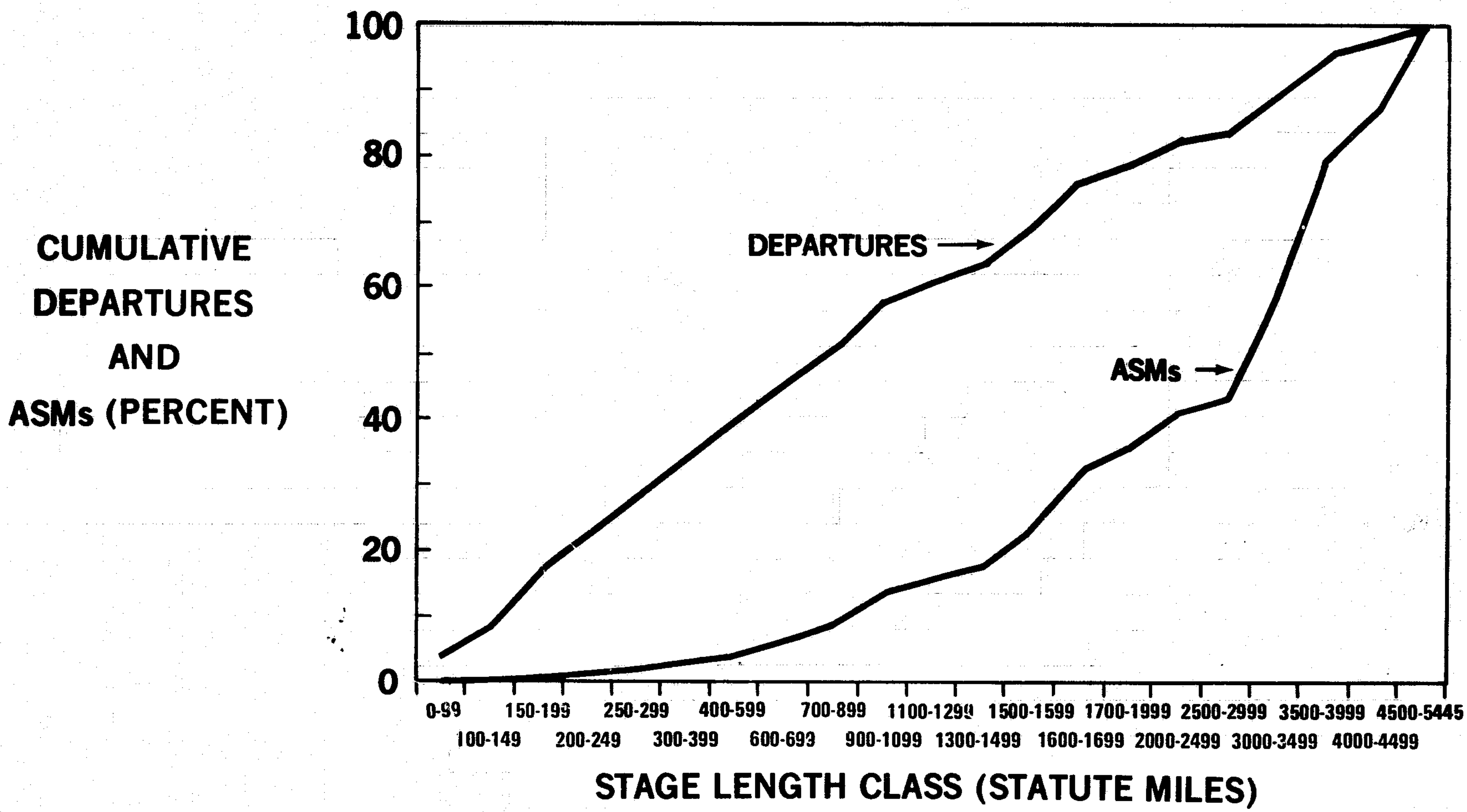


FIGURE 70. 1974 ANNUAL DEPARTURE AND ASM DISTRIBUTION BY RANGE

TABLE 66

STAGE LENGTH CLASSES

CLASS	STAGE LENGTH (STATUTE MILES)	ANNUAL DEPARTURES (%)	ANNUAL ASMs (%)
1	0 - 99	4.3	.1
2	100 - 149	4.1	
3	150 - 199	8.5	.8
4	200 - 249	5.8	
5	250 - 299	6.2	1.4
6	300 - 399	5.6	.8
7	400 - 599	5.7	1.4
8	600 - 699	5.4	2.1
9	700 - 899	5.2	2.7
10	900 - 1099	6.9	4.2
11	1100 - 1299	3.6	2.2
12	1300 - 1499	2.6	1.9
13	1500 - 1599	5.7	5.6
14	1600 - 1699	6.9	9.0
15	1700 - 1999	2.5	4.0
16	2000 - 2499	3.6	5.4
17	2500 - 2999	1.3	1.7
18	3000 - 3499	5.1	15.8
19	3500 - 3999	6.2	20.6
20	4000 - 4499	2.4	7.0
21	4500 - 5445	2.4	13.3
	TOTAL	100.0	100.0

4.3 Airline Consultations

Basic to this study was a review of the general fuel cost trends, the operational realism of various means of conserving fuel, and the anticipated growth in the market for the U.S. international scheduled carriers. To assure that this market study accurately reflected the actual operations of the carriers, three U.S. international airlines were contacted: Pan American World Airways, Trans World Airlines, and Northwest Airlines. The discussions centered around several general topics.

- Experience on the airline's network with operational variations, and the impact of drag reduction programs, interior modifications (increased seating density), as well as Aerosat on fuel savings.

- Advanced technology developments that would most benefit U.S. international carriers.

- The effect of speed reductions on international operations.

- Future expectations with respect to jet fuel supplies and prices at both domestic and foreign airports. Unique fuel problems related to the airline's system - operational and/or political.

- Discussion of the international market and its characteristics including anticipated growth through 1990.

4.3.1 Operational Variations and Air Traffic Control

All three U.S. international carriers consulted are using some form of fuel useage control data system including computerized flight planning to minimize fuel consumption on each flight, as well as fuel allocation models for all or critical airports on route. However, they all expressed the limitations they face in improving fuel efficiency through operational variations. For example, flexibility with respect to seating configurations is constrained by IATA which in its rate making decisions defines aircraft pitch and capacity, though not mix. Also, the present air traffic control system does not permit the use of cruise climb procedures.

As a result of the energy crisis, the airlines, particularly Northwest, have reemphasized maintaining their aircraft in terms of cleaning, washing, and repairing dents in order to minimize drag and be as fuel efficient as possible. Also, most international carriers are now flying minimum time tracks which account for winds and may cover more ground distance but result in less air distance and flight time, thereby, reducing fuel consumption.

The biggest problem the airlines are facing in increasing fuel efficiency concerns the present air traffic control system. The pre-flight determination of the amount of fuel to load including reserves is more critical on some international routes than domestically due to the longer non-stop stage lengths flown. Another ATC problem is the limited number of lanes or airways available on international routes. The lanes become crowded as a function of time with saturation occurring at peak customer-choice hours. As this occurs, the airlines can no longer get to the desired altitude for a minimum fuel flight. Therefore, these carriers do see fuel conserving benefits occurring from an improved ATC system that provides for cruise climb procedures, decreased altitude separations, and linear holding rather than circling over an airport.

The airlines were not really enthusiastic about Aerosat in improving their fuel efficiencies. They felt that its useage was too far in the future, and that the present Aerosat concepts were inadequately focused and hard to justify economically for use in commercial airline service.

The impact of improved navigational aids on fuel conservation was also discussed. Although improved systems including 4-D RNAV offer a significant potential for fuel savings, the airlines see limitations on their near-term use. For instance, 4-D RNAV cannot increase airport runway or gate capacity at the peak customer-choice hours which would reduce delays and fuel burned. Also, on-board computers can benefit fuel useage in climb and descent by 2-5 percent, but effective use of this equipment is also limited by the present ATC system.

4.3.2 Advanced Technology Developments

In early 1976 when these discussions took place, the carriers were primarily interested in becoming as fuel efficient as possible with the aircraft they had available and were only casually interested in new advanced technology concepts for reducing fuel. However, as the sizeable fuel savings achievable with new designs are further documented, their interest will accelerate, especially as fuel prices continue to rise and airline profits improve.

None of the airlines were enthusiastic about retrofitting their current aircraft with advanced technologies, such as new engines, to conserve fuel. The payback period allowed by their financial lenders for a capital improvement is so short at present, 1-3 years, that in most cases it is uneconomic to retrofit. The airlines would rather replace old seats with newer more competitive equipment which incorporates advanced technologies in other areas, as well as offering substantial improvements in fuel efficiency.

4.3.3 Reduced Cruise Speed

The airlines were not against slowing down to conserve fuel, and in fact have been doing so since the energy crisis. They have found that a small change in Mach number (e.g., M 0.82 to M 0.80) did not change DOC's appreciably, nor did crew costs increase noticeably.

Of the elements of airline direct operating costs, it is the crew, fuel, and maintenance costs that are related to flight time. Crew costs are no longer so heavily related to flight time since union contracts at present guarantee the number of hours the crew gets paid for a specific flight, regardless of whether the actual flight takes slightly more or less time to complete.

Maintenance costs also are not 100 percent speed sensitive. At present they are possibly 15 percent related to speed, but this varies for each aircraft type. Maintenance costs for the new widebody aircraft are the least related to speed, and in fact, cyclic maintenance costs are the most important today due to the heavy use of on-condition maintenance procedures. With this method, maintenance items are checked against physical or chemical standards and are not necessarily removed. TWA's L1011 airplanes, for example, are over 90 percent on-condition maintained.

4.3.4 Fuel Supplies and Prices

Fuel availability has not been a significant problem for the U.S. international carriers even during the energy crisis of late 1973. Rising fuel prices are their principal concern, and they estimate the average system price per gallon of fuel internationally to be near 70-75 cents by 1985. Northwest's approach to increasing fuel prices has been to view fuel cost as only one of the costs of operating an airline, and to strive for a minimum cost operation overall.

The airlines apparently have not run into many political problems with respect to fuel supplies or prices at international airports. Northwest did mention that they had experienced problems with several foreign governments in the past but not regarding aircraft fuel. Instead these governments imposed frequency limitations on Northwest, forcing the airline into operating bigger aircraft in those international markets.

4.3.5 U.S. International Market Growth

Predictions on U.S. international traffic growth during these discussions in February 1976, were guardedly optimistic. All the carriers forecasted growth in the market for 1976, and at the very least, continued moderate growth through 1990. They agreed that use of the Douglas average annual growth rate of 4.6 percent over the 1974-1990 forecast period was realistic for the purposes of this study.

4.3.6 Summary

All three airlines contacted were very interested in means to further reduce fuel consumption below what they've already achieved. As the economic condition of the country as well as of the airline industry has improved, the carriers continued to actively pursue new ways of conserving fuel, including the preliminary reviewing of new fuel conserving aircraft designs. They also see significant fuel savings accruing from an improved air traffic control system, and recommend further study to determine just how large the benefits would be to the U.S. international carriers. Any study of this subject would also have to include an investigation of the costs that would be incurred in improving the system as well as the sharing of these benefits and costs with the U.S. domestic airlines.

The importance of even small fuel savings to the airlines should not be underrated. For example, TWA expressed the fact that a 1/2 to 1 percent savings in fuel annually on their B707 fleet could result in a $1 million cost savings per year. The impact of even a small percentage in fuel savings becomes very significant when viewed in this light.

4.4 Aircraft Characteristics and Direct Operating Costs

In the domestic study, the airline contractor adjusted the Douglas engineering and cost data in order to bring the idealized handbook block fuel and block time data, as well as the operating costs based on this data, up to realistic airline levels. As shown in Volume 1, Section 1, actual airline fuel use is approximately 30 percent higher than the calculated fuel burns using engineering handbook data. However, the study of aircraft designed for the international routes of the U.S. carriers was conducted independently by Douglas, without the assistance of an airline contractor. For this reason, and also because the international study included Boeing and Lockheed airplanes in addition to the Douglas airplanes, the block fuel, block time, and DOC characteristics for the study aircraft were derived from a statistical reduction of annual 1974 Civil Aeronautics Board (CAB) and August 1974 Official Airline Guide (OAG) data.

4.4.1 Baseline Aircraft in the International Market

Passenger versions of Boeing, Lockheed, and Douglas turbofan commercial transports currently in the fleets of the U.S. international scheduled carriers were chosen as the baseline aircraft. These fleets included aircraft from the following families: DC-8, DC-9, DC-10, L1011, B707, B720, B727, and B747. The actual baseline models and their characteristics are given in Table 67. The general characteristics were based upon manufacturers' published data, while the seat densities were based on the average 1974 capacities reported by the airlines to the CAB.

TABLE 67

BASELINE AIRCRAFT CHARACTERISTICS

International Study Aircraft	No. of Seats	TOGW (lb)	Study OEW (lb)	Cruise Mach Number	Engines (No., Type, TSLS/Eng (lb))	Design Range (NM)
DC-8-50	148	300,000	132,000	.82	4, JT3D-3B, 18,000	4180
DC-8-62	164	350,000	145,000	.82	4, JT3D-3B, 18,000	5250
DC-9-30	97	108,000	57,900	.80	2, JT8D-7, 14,000	1660
DC-10-10/L1011	240	430,000	237,200	.85	3, CF6-6D, 40,100	3940
B707-100B	130	257,000	123,200	.82	4, JT3D-3B, 18,000	3720
B707-300B	153	327,000	137,200	.82	4, JT3D-3B, 18,000	5550
B707-300C	146	334,000	145,000	.82	4, JT3D-3B, 18,000	5460
B720B	119	235,000	119,000	.82	4, JT3D-3B, 18,000	3150
B727-100	107	169,000	88,500	.82	3, JT8D-7, 14,000	2210
B727-200	131	172,000	97,400	.84	3, JT8D-9, 14,500	1680
B747-100	368	735,000	364,000	.85	4, JT9D-7, 47,000	4650

Block time, block fuel, and DOC characteristics for the baseline aircraft were derived from operational statistics provided by the OAG and CAB. A Douglas computer program which weights the OAG scheduled trip time statistics by frequency was used to provide operational block time versus range equations for each aircraft type. Another Douglas program which compiles the CAB statistics by equipment type, air carrier, service category, and service area was used to provide the weighted average range, as well as the fuel consumption and DOC per trip at that range for each aircraft type. The reduced OAG and CAB data in combination provided the operational DOC and fuel consumption versus range equations used for each baseline aircraft under study.

The operational block time, fuel, and cost equations generated by this technique are linear functions of range. They very closely approximate the functional form of data developed by engineering performance methods and the ATA DOC method, but they more accurately represent actual airline operational experience.

4.4.2 Derivative Aircraft Options

Four derivative aircraft were studied for the future international market. The DC-10-10D is a shortened twin-engine version of the DC-10-10 with an all-new supercritical wing. The DC-10-30D1 is a modification of the existing intercontinental range DC-10-30. Relative to the DC-10-10, the DC-10-30D1 has extended wing tips, center-wing fuel tanks, higher thrust engines, and general drag and weight reduction items. The DC-10-30D2 involves a 30 foot fuselage stretch, winglets, and general drag and weight reduction programs. The B747D also includes general drag and weight reductions, and has accommodations for 32 additional passengers on the upper deck. General characteristics of the derivative aircraft are given in Table 68. Additional data on the DC-10-10D aircraft option, winglets, as well as the general drag and weight reduction items studied can be found in Volume I.

TABLE 68

DERIVATIVE AIRCRAFT OPTION CHARACTERISTICS

AIRCRAFT CHARACTERISTICS	DC-10-10D	DC-10-30D1	DC-10-30D2	B747D
Number of Seats	199	252	327	400
TOGW (lb)	283,000	555,000	572,000	738,000
OEW (lb)	160,800	267,600	274,700	370,000
Cruise Mach Number	.82	.85	.85	.85
Engines: Number	2	3	3	4
Type	CF6-50	CF6-50C	CF6-50J	JT9D-7
TSLS/Eng (lb)	46,600	51,000	54,000	47,000
Design Range (NM)	3,050	5,470	4,710	4,900

A statistical analysis of the operational block time, fuel, and DOC equations for the baseline aircraft showed a high correlation (r^2 = 91 to 99 percent) between (1) the constants and slopes of these equations, and (2) either aircraft design cruise Mach number or Operator's Empty Weight (OEW). Therefore, on these bases, new block time equations were formulated for the derivative airplanes, and the non-fuel portions of their DOC equations were determined. The derivative aircraft block fuel equations were then derived by adjusting the baseline aircraft fuel equations to reflect the derivative design changes. The resulting fuel costs were then added to the DOC equations to generate total DOC cost equations at the two study fuel prices of 30 cents and 60 cents per gallon.

4.4.3 New Near-Term (1980) Aircraft

Two intercontinental range families of new near-term aircraft were also studied. These airplanes were designed to NASA specifications and incorporated technology consistent with a 1980 introduction date. The airplanes designed in each N80 aircraft family were optimized for a specific parameter of either maximum fuel efficiency (minimum fuel burned) or minimum DOC at a fuel price of 30 cents or 60 cents per gallon. This resulted in six all-new aircraft options. Additionally, another two designs, one for each aircraft family, were optimized for minimum DOC's with fuel at 15 cents per gallon, using trends established in the domestic N80 study. These airplanes were used as "benchmarks" in developing operational block time, fuel, and DOC equations for the six study aircraft. Table 69 presents the general characteristics of the study international N80 airplanes. A full description of the new near-term (1980) aircraft, both domestic and international configurations, can be found in Section 5.0 of Volume I.

<u>Development of N80 Operational Block Time, Fuel, and DOC Equations</u> - The block time equations used for the N80 aircraft were developed on the same bases as those for the derivative aircraft options. The maneuver time constants in the N80 operational block time equations were based on Operator's Empty Weight, while the slopes (1/velocity) were determined from the respective N80 design cruise Mach numbers. The operational block fuel equations were

TABLE 69

NEW NEAR-TERM (1980) AIRCRAFT CHARACTERISTICS

Characteristics \ Optimization Parameter	N80-2.55			N80-4.55		
	DOC_{30}	DOC_{60}	Block Fuel	DOC_{30}	DOC_{60}	Block Fuel
Number of Seats	201	201	201	404	404	404
TOGW (lb)	375,100	367,500	386,900	704,700	701,400	747,600
OEW (lb)	184,400	186,000	208,900	361,200	368,400	420,400
Cruise Mach Number	0.82	0.78	0.70	0.82	0.79	0.70
Design Range (NM)	5,500	5,500	5,500	5,500	5,500	5,500
Engines: Number	4	4	4	4	4	4
Type	CFM-56	CFM-56	CFM-56	CF6-6	CF6-6	CF6-6
TSLS/Eng (lb)	22,720	20,240	17,780	40,240	37,290	35,160

generated in two steps. First, the operational fuel equation constants for the "benchmark" DOC_{15} designs were obtained on the basis of OEW from the baseline aircraft data. Then adjustments were made for the fuel use differences between the "benchmark" DOC_{15} aircraft and the other three airplanes in each family, using fuel use ratios based upon engineering design data.

The non-fuel portions of the DOC equations for the six N80 airplanes were synthesized as functions of OEW based upon the statistical analysis conducted on the DOC's of the baseline aircraft. Fuel costs were added into the DOC equations as functions of the two study fuel prices, 30 cents and 60 cents per gallon.

4.5 Indirect Operating Costs

Since IOC's are so heavily traffic, revenue, and airline related, the RECAT Study contractors and NASA agreed to use the updated 1969 Lockheed Committee IOC formula to calculate these costs for the U.S. domestic study. This IOC method allows for the computation of comparable and compatible average indirect operating costs for each aircraft type studied. To be consistent with the domestic study, this formula, updated to estimate 1974 cost levels, was also used in the international study. However, the coefficients documented in the IOC equations on page 86 (Figure 36) were changed to reflect U.S. international operations.

The coefficients that were used to estimate 1974 cost levels were actually three year, moving averages of each IOC coefficient in the equations. The yearly coefficients that these moving averages represented had been developed by Lockheed to reasonably duplicate the combined IOC's of several U.S. international carriers when applied to the selected operating statistics in the equations. This combined IOC data reflected the international system IOC expenses of the big three U.S. international scheduled carriers, (TW, NW, and PAA), as reported to the CAB for the years 1971, 1972, and 1973. Since the 1971-1973 coefficients for each Lockheed cost category did not vary significantly from year to year, nor from their respective three year, moving averages, it was assumed that the 1974 coefficients yet to be determined would be reasonably close to the averages. This assumption seemed reasonable for the purposes of estimating comparable 1974 IOC's for the competitive aircraft options under study.

Additional assumptions used in calculating the IOC's for each aircraft type are given in Figure 71. Further discussion of indirect operating costs in general as well as of the Lockheed Committee IOC Formula can be found in Section 2.6.

4.6 Total Operating Revenue

The operating revenue generated from scheduled passenger services had to be determined in order to carry out the objective criterion of maximizing the operating profit for each fleet forecast. For this study operating profit was defined as total operating revenue less total operating costs. This operating profit excludes interest and tax charges and, therefore, shows the actual economic viability of the total fleet forecast before financing costs and taxes. Total operating revenue included revenue from scheduled passenger services including cargo carried on passenger flights.

4.6.1 Passenger Revenue

The revenue generated by a particular fleet of aircraft over the forecast period 1974-1990 was based upon the airline revenue data documented in "Airline Industry Data - U.S. Trunkline Carriers and Pan American," June 5, 1975 and shown in Table 70. This report is issued by the McDonnell Douglas Finance Corporation and details the operating and financial statistics of the U.S. airlines by carrier as well as operations area. The source of this data is primarily fron the CAB's Form 41 Reports.

The 1974 passenger revenue for each operating area of the U.S. carriers serving the international market was divided by its respective 1974 revenue passenger-miles to determine the various average yields per RPM in 1974. These yields were then multiplied by the corresponding 1974 average stage lengths for each airline's operating areas to establish the average revenues

- UPDATED LOCKHEED IOC COEFFICIENTS FOR THREE MAJOR U.S. INTERNATIONAL CARRIERS (REPORT NO. COA/1277, JUNE 1974)
- LOAD FACTOR 58 PERCENT
- FREIGHT CARRIED BASED ON UAL EXPERIENCED TONNAGE BY AIRCRAFT TYPE
- CARGO REVENUE - 3 PERCENT OF TOTAL REVENUE GENERATED BY SCHEDULED PASSENGER SERVICE
- CARGO TONNAGE AND CABIN ATTENDANTS ASSUMED BY AIRCRAFT TYPE

	CABIN ATTENDANTS	CARGO TONS
DC-8/B707/B720B*	6	.78
DC-9-30	3	.46
B727-100	4	.50
B727-200	4	.68
DC-10/L1011	10	2.60
DC-10-10D	8	2.60
DC-10-30M	10	2.60
DC-10-30D	12	2.60
B747-100/B747D	12	3.50
N80-2.55 FAMILY	8	1.70
N80-4.55 FAMILY	12	3.50

- IOCs NOT EXPECTED TO VARY WITH FUEL PRICE INCREASES

*INCLUDES DC-8-50, DC-8-62, B707-100, B707-300B, B707-300C, B720B

Figure 71. INDIRECT OPERATING COST ASSUMPTIONS - 1974 DOLLARS

TABLE 70

1974 INTERNATIONAL REVENUE BY AIRLINE

Airline - Operating Area	Psgr. Revenue* ($ Millions)	RPM's* (Millions)	Avg. Yield ¢/RPM	Avg. Stage Length* (St.Mi.)	Avg. Revenue Per Psgr. ($)
AA	128.6	2304.5	.0558	1246	69.53
BN	102.7	1378.2	.0745	1085	80.83
EA	235.7	3710.2	.0635	709	45.02
NA	17.3	288.9	.0599	4406	263.92
NW	140.5	2394.0	.0587	2237	131.31
PAA-ATL	497.2	7178.2	.0693	1024	70.96
PAA-LAT	258.7	3945.3	.0656	1145	75.11
PAA-PAC	222.9	3500.7	.0637	2501	159.31
TW	444.6	7382.7	.0602	2193	132.02
WA	34.9	555.4	.0628	1561	98.03

*Source: "Airline Industry Data - U.S. Trunkline Carriers and Pan American," McDonnell Douglas Finance Corporation, Report C1-MDFC-JFM-66, June 5, 1975.

per passenger in 1974. These data points, also given in Table 70, were plotted along with several TW yields in specific markets and weighted subjectively by the relative RPM's involved. Three linear average passenger revenue versus range classes were constructed from the plotted data as shown in Figure 72. The passenger revenues produced by each fleet forecast in this U.S. international market study were then calculated using the three range-class equations given in Table 71.

TABLE 71

1974 PASSENGER REVENUE VS. STAGE LENGTH EQUATIONS

Class No.	Stage Length Increment (St.Mi.)	Average Revenue ($/Trip/Psgr)
1	≤900	12.00 + .05667 x Range
2	>900 ≤2000	16.36 + .05182 x Range
3	>2000	-3.00 + .06150 x Range

4.6.2 Cargo Revenue

Revenue produced from cargo operations conducted on scheduled passenger flights was based upon a system estimate of the relationship between cargo revenue and passenger revenue on these flights. This relationship was provided by United Airlines and was used in the Domestic RECAT Study as well. It estimated cargo revenue at 3 percent of the total passenger revenue.

4.7 Development of Fleet Forecasts

4.7.1 Baseline Operating Scenarios (1974-1990)

A baseline scenario (No. 1, Tables 72 and 73) was developed to reflect the airline environment in which the U.S. international carriers operated during 1974. This scenario included 1974 operating procedures, a constant dollar fuel price of 30 cents per gallon, 1974 derived passenger yields (Section 4.6.1, Table 71), a goal load factor of 58 percent, and 1974 frequencies as a minimum. No maximum frequency levels were established for this preliminary international market study. Also, the availability of fuel was unlimited

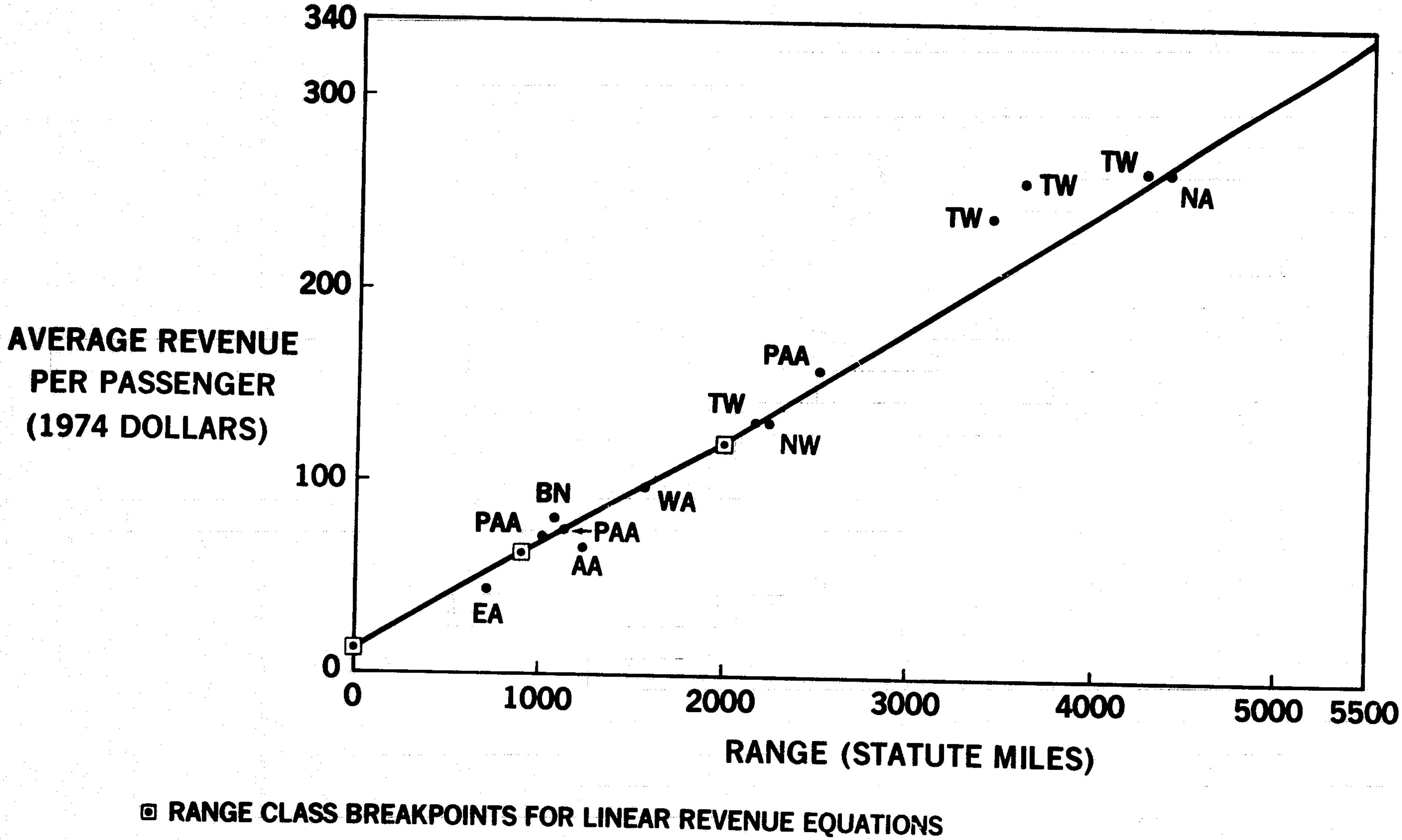


FIGURE 72. 1974 U.S. INTERNATIONAL REVENUE DEVELOPMENT

TABLE 72

DEVELOPMENT OF FLEET FORECASTS - RUN SCHEDULE

OBJECTIVE - MAXIMIZE AIRLINE PROFIT

Scenario No.	FLEET INVENTORY OPTIONS			LOAD FACTOR		FUEL AVAILABILITY		FUEL PRICE		Scenario Description
	Exist A/C	Deriv. A/C	New Near Term	Goal 58%	Inc. L.F. 70%	No Limit	1974 Level	30¢	Inc. Price 60¢	
1	X			X		X		X		Baseline 30¢
2	X	X		X		X		X		Screen derivatives 30¢
3	X	S		X		X		X		Selected derivatives 30¢
4	X	S	X	X		X		X		Screen selected derivatives with N80's 30¢
5	X			X		X			X	Baseline 60¢
6	X	X		X		X			X	Screen derivatives 60¢
7	X	S		X		X			X	Selected derivatives 60¢
8	X	S	X	X		X			X	Screen selected derivatives with N80's 60¢
9	X	S	X		X	X			X	Screen derivatives, N80's @ 70% L.F., 60¢
10	X	S	S		X	X			X	Selected derivatives +N80's @ 70% L.F., 60¢
11	X	S	X		X		X		X	Screen selected derivatives with N80's @ 70% L.F. w/fuel constraints, 60¢

S = Selected Options

TABLE 73

AIRCRAFT TYPES OFFERED IN EACH U.S. INTERNATIONAL SCENARIO

Scenarios

AIRCRAFT TYPE	1	2	3	4	5	6	7	8	9	10	11
Fuel Price	← 30¢ →				← 60¢ →						
DC-8*	X	X	X	X	X	X	X	X	X	X	X
DC-8-62	X	X	X	X	X	X	X	X	X	X	X
DC-9-30	X	X	X	X	X	X	X	X	X	X	X
DC-10 / L1011	X	X	X	X	X	X	X	X	X	X	X
B707-300B	X	X	X	X	X	X	X	X	X	X	X
B707-300C	X	X	X	X	X	X	X	X	X	X	X
B727-100	X	X	X	X	X	X	X	X	X	X	X
B727-200	X	X	X	X	X	X	X	X	X	X	X
B747	X	X	X	X	X	X	X	X	X	X	X
DC-10-10D		X	X	X		X	X	X	X	X	X
DC-10-30M		X				X			X		
DC-10-30D		X	X	X		X	X	X	X	X	X
B747D		X				X			X		
$N80\text{-}2.55_{30}$				X				X	X		X
$N80\text{-}2.55_{60}$				X				X	X	X	X
$N80\text{-}2.55_{MF}$				X				X	X		X
$N80\text{-}4.55_{30}$				X				X	X		X
$N80\text{-}4.55_{60}$				X				X	X		X
$N80\text{-}4.55_{MF}$				X				X	X		X
TOTAL NUMBER OF AIRCRAFT TYPES	9	13	11	17	9	13	11	17	19	12	17

* Includes DC-8-50, B707-100, B720B

throughout the study period, 1974-1990. Only the existing aircraft types in this market still in production in 1974 were available for purchase to meet subsequent aircraft demand through 1990. This first baseline scenario, based on the assumed average annual RPM growth rate of 4.6 percent, establishes an upper limit on fuel demand for the U.S. international carriers during the period 1974-1990. It represents the highest fuel consumption case since fuel availability was unlimited and no fuel conserving aircraft options were allowed to serve the market.

An additional baseline scenario (No. 5) reflected the same operating environment as the first scenario except that the fuel price was 60 cents per gallon. The fleet forecast results from both these baseline scenarios were used as the reference cases against which the results achieved under the alternative operating scenarios discussed in Section 4.7.2 were measured.

4.7.2 Alternative Operating Scenarios

Nine alternative scenarios were developed in which the operational constraints in the baseline scenarios were varied during the 1974-1990 forecast period. These changes involved fuel availability, load factor, as well as the different offerings of aircraft options as shown in Table 72. The effects of these changes on both fuel savings and fleet requirements as well as other operating statistics were then assessed. In each of these scenarios, subsequent aircraft needs were met not only with additional numbers of existing 1974 aircraft types, but also with the fuel conserving options under study. These aircraft options described in Section 4.4 included four derivatives of airplane types already existing in the international market as well as six all-new 1980 technology designs. The different offerings of aircraft options available for selection by the market in each scenario are given in Table 73. It should be noted that in each scenario the existing aircraft in the fleet that were still in production in 1974 were always offered to the market along with the different offerings of fuel conserving aircraft options.

<u>Scenarios With Fuel at 30 Cents per Gallon</u> - Three scenarios (Nos. 2-4) were used to screen and select the most promising fuel conserving aircraft options assuming a fuel price of 30 cents per gallon. These scenarios were identical to the baseline scenario with fuel at 30 cents per gallon except in the offerings of airplane types to meet subsequent aircraft demand through 1990. First, all

four derivatives of aircraft currently in the U.S. international fleet were offered to the market. Next, only those derivatives selected as viable options in the previous scenario were available in the market. Lastly, the selected derivatives and the six all-new N80 airplanes were offered in the market.

Scenarios With Fuel at 60 Cents Per Gallon - An additional six scenarios (Nos. 6-11) were developed to further screen the potentially viable aircraft options. The first three scenarios (Nos. 6-8) were essentially the same as the second baseline scenario which had a fuel price of 60 cents per gallon. However, the offerings of aircraft types through 1990 were varied for each scenario as they had been in the 30 cents scenarios. First, the four derivative airplane types were offered to the market. Then, in the next scenario, only the selected options from the original group of four derivatives were available for purchase, and finally, in the third scenario the selected derivatives competed with the six new near-term 1980 airplanes. Using these three scenarios, the aircraft options selected and the number of each type needed in the fleet for each scenario with fuel at 60 cents per gallon were compared with those options selected and the numbers required when fuel was at 30 cents per gallon.

The next three scenarios (Nos. 9-11) with fuel at 60 cents per gallon measured the impact of an increased goal load factor of 70 percent as well as fuel constraints on the fleet selection (size and mix) as well as fuel savings and RPM demand. Since the U.S. international airlines were already paying around 30 cents per gallon for fuel in 1974, it seemed more appropriate to test the impact of varying these operational constraints under an airline environment where fuel was higher than 30 cents per gallon. At a higher fuel price, operational alternatives such as increased load factors and the optimized use of allotted fuel supplies become more attractive.

Therefore, in the ninth scenario the goal load factor of 58 percent was changed to 70 percent, and all ten aircraft options, (four derivatives plus six N80's), were offered to the market. In the next scenario, only the selected aircraft options from the preceding scenario were available to meet subsequent aircraft demand. In the last case, a fuel supply equivalent to the total fuel burned by the U.S. international fleet in 1974 was allotted to the market each year through 1990. Also the previously selected derivative options were offered to the market along with the six all-new N80 airplanes.

4.8 Results of Fleet Forecasts

The fleet forecast results for this U.S. international market study have been documented for the years 1976-1990. However, the revenue passenger-miles and the fleet size and mix under each scenario were actually forecasted from 1974-1990. This was done in order to focus on the future fuel savings and profit improvements possible with the use of the most promising fuel conserving aircraft options in the fleets. The results of the study will not be changed in any way since both 1974 and 1975 represent past history, and the actual 1974 operational data for this market was used in the study as the base year.

4.8.1 Revenue Passenger-Miles

The fleets required for each scenario throughout the forecast period performed all the forecasted revenue passenger-miles from 1974-1990 with the exception of the fleet selected under the fuel constrained environment. In 1990 only 78 percent of the potential RPM's were flown under this scenario, and over the 1976-1990 time period only 88 percent of the RPM's were performed.

4.8.2 Fleet Sizes

The required fleet size for each scenario by selected years are given in Table 74. Each fleet is composed of a different number and mix of aircraft types, but the total fleet size under each scenario does not vary substantially. The 1980 fleet size for the U.S. international carriers was estimated at 260-265 aircraft, an increase from 230 airplanes in the fleet in 1974. By 1990 the required fleet grew to 320-330 airplanes.

The number of airplanes needed in the fleet when the goal load factor was increased to 70 percent was less than that with a load factor of 58 percent. The number of aircraft demanded in 1990 with a goal load factor of 70 percent was 287 versus 321 with a 58 percent load factor. Also the fleet size required under a fuel constrained scenario was considerably smaller, 226 airplanes in 1990, due to the lack of ability to perform all the RPM demand within the allocated fuel levels.

TABLE 74

U.S. INTERNATIONAL FLEET SIZES BY YEAR

Scenario Description & Fuel Price (¢/Gal)	1976	1980	1985	1990
Baseline @ 30¢	241	269	336	388
All Derivatives @ 30¢	241	261	289	334
Selected Derivatives @ 30¢	241	261	291	328
Selected Derivatives, N80's @ 30¢	241	258	288	322
Baseline @ 60¢	240	269	331	364
All Derivatives @ 60¢	240	263	287	325
Selected Derivatives @ 60¢	240	263	284	328
Selected Derivatives, N80's @ 60¢	240	261	285	321
N80s* + 70% L.F. @ 60¢	240	261	263	287
N80s* + 70% L.F. + Fuel Alloc. @ 60¢	230	230	227	226

*N80's = Derivatives + N80's

4.8.3 Selected Aircraft Options

Although the types and numbers of each airplane required in each scenario varied, certain aircraft options were selected in sufficient quantity by the market in almost every scenario as shown in Table 75. Out of the ten airplanes studied, two were selected as the most promising for fuel conservation, as well as being the most economically and operationally viable under the two fuel environments examined.

Initially, the four derivative aircraft options were offered to the market along with the existing baseline airplanes. Two derivatives, the DC-10-10D and the DC-10-30D2 were selected at both fuel prices and under both fuel environments. The DC-10-10D is a shortened DC-10-10 configured for 199 seats, while the DC-10-30D2 is a stretched DC-10-30 with 327 seats. In the next scenarios, when these selected derivatives and all six study N80's were available to meet subsequent aircraft demand, the derivatives were still very viable in the U.S. international market.

TABLE 75

MOST PROMISING AIRCRAFT OPTIONS FOR FUEL CONSERVATION

U.S. INTERNATIONAL MARKET

Number of Study Options	Unconstrained Fuel Environment	Constrained Fuel Environment
4 Derivatives	DC-10-10D	DC-10-10D
	DC-10-30D1	DC-10-30D1
	DC-10-30D2	DC-10-30D2
	B747D	B747D
6 New Near-Term	N80-2.55$_{30}$	N80-2.55$_{30}$
	N80-2.55$_{60}$	N80-2.55$_{60}$
	N80-2.55$_{MF}$	N80-2.55$_{MF}$
	N80-4.55$_{30}$	N80-4.55$_{30}$
	N80-4.55$_{60}$	N80-4.55$_{60}$
	N80-4.55$_{MF}$	N80-4.55$_{MF}$

= Selected Viable Options

= Selected Nonviable Options

Four of the six N80 airplanes were selected in the various scenarios, but no all-new aircraft was really viable nor flexible enough to be desired in a scenario other than the ones that matched its particular design characteristics. For instance, the N80-2.55$_{30}$ and N80-4.55$_{30}$ airplanes were chosen only in the scenarios where fuel price was 30 cents per gallon. The N80-2.55$_{60}$ was selected in the scenarios with fuel at 60 cents per gallon regardless of load factor, and the N80-2.55$_{MF}$ option was chosen only under the fuel constrained scenario. The N80-4.55$_{60}$ and N80-4.55$_{MF}$ airplanes were not utilized in any scenario due to their higher operating costs and larger than needed seating capacity.

Table 76 shows the potential U.S. international market demand for each of the six selected options. As can be seen, both derivative options achieved feasible market sizes, while no selected N80 aircraft was heavily demanded by the market under any of the simulated airline environments studied. This fact becomes more apparent in the fuel burn results in Section 4.8.5. It should be noted that the potential market sizes given in the table do not include the demand from foreign carriers for these selected aircraft options.

TABLE 76

POTENTIAL MARKET SIZES
(1990)

Selected Aircraft Options	U.S. International Aircraft Market
Derivatives	
DC-10-10D	50
DC-10-30D2	60
New Near-Term Aircraft	
N80-2.55$_{30}$	15
N80-2.55$_{60}$	14
N80-2.55$_{MF}$	21
N80-4.55$_{30}$	22

4.8.4 Profit Improvement

The Performance Evaluation Technique was used to determine the best fleet-mix by year from 1974-1990 for each operating scenario. It selected from the airplanes offered to the market in that particular scenario those aircraft types and numbers that best satisfied the traffic demand as well as met the study evaluation criterion of maximizing airline profits. In comparing the viability of the aircraft options, the profit achieved by each fleet due to the addition of selected aircraft options was compared to the profit generated by the baseline fleet forecasts at fuel prices of 30 cents and 60 cents per gallon respectively, as shown in Table 77.

TABLE 77

COMPARATIVE FLEET FORECAST PROFIT RESULTS ($ Per RPM)

Scenario Description & Fuel Price (¢/Gal)	Cumulative Profit Improvement (Percent)	
	1976-1990	1980-1990
Relative to Baseline Scenario with Fuel at 30¢ Per Gallon		
Selected Derivatives @ 30¢	5.6	6.8
Selected Derivatives, N80's @ 30¢	7.0	8.5
Relative to Baseline Scenario with Fuel at 60¢ Per Gallon		
Selected Derivatives @ 60¢	33.4	35.2
Selected Derivatives, N80's @ 60¢	38.5	40.5
N80's* + 70% L.F. @ 60¢	147.3	154.9
Relative to N80's* Scenario, 70% L.F., with Fuel at 60¢ Per Gallon		
N80's* + 70% L.F. + Fuel Alloc. @ 60¢	3.6	5.9

*N80's = Derivatives + N80's

Profits in the simulated airline environments were improved significantly based upon the optimum fleet-mix of aircraft options selected for that scenario. Since the selected airplanes were not introduced until 1980, the cumulative results during 1980-1990 were more representative of the profit improvement that could be expected from the study airplanes.

When the two selected derivative options were added into the baseline fleet, profits increased by almost 7 percent when fuel was at 30 cents per gallon and by 35 percent at 60 cents per gallon. In the higher fuel price environment, the fuel conserving derivative aircraft types become more viable, increasing overall fleet profitability. However, the profit generated by the baseline 60 cents fleet was only 30 percent of that achieved with the baseline fleet with fuel at 30 cents per gallon. This was because the fares were not raised above the 1974 levels. Realistically, fares would have to be increased if the price of fuel was 60 cents per gallon.

The addition of the selected N80 options to the fleet of baseline airplanes and selected derivatives did increase profits above those achieved with only the selected derivatives included in the fleet. However, as can be seen in the table, the additional profit at the same 1974 fare levels from the selected N80's was not substantial. The fleet forecast with a higher 70 percent load factor and a fuel price of 60 cents per gallon significantly increased airline profits to within 70 percent of those achieved with the 30 cents N80 scenario at the study load factor of 58 percent.

The selected N80 fleet forecast based upon a limited fuel environment with fuel at 60 cents per gallon and a 70 percent goal load factor, improved profit per RPM by 6 percent during 1980-1990 over the N80 fleet selected under the same operational environment but with no fuel constraints. However, since this fleet did not perform all the forecasted RPM demand, actual dollar system profit was lower than it was for the unconstrained fuel fleet.

4.8.5 Fuel Consumption and Savings

The fuel conserving fleet forecasts were developed to represent the U.S. international air transportation system in both an unlimited as well as a restricted fuel environment. Fuel supplies were constrained to the 1974 levels through 1990 in the fuel restricted scenario. This allocation level by 1990 provided only 58 percent of the fuel required by a mixed fleet of selected options (baseline airplanes, derivatives, and N80's) in an unconstrained fuel environment that year. The resulting fuel requirements for each fleet forecast were evaluated to define reasonable bounds around the potential jet fuel demand in this market from 1976-1990.

The fuel consumed by the fleet forecasted under each scenario is given in Table 78. For comparison purposes, four time periods are shown: annually for 1980 and 1990, as well as cumulatively for 1976-1990 and 1980-1990. The cumulative time period, 1980-1990, was included since the majority of the aircraft options were introduced to the market in 1980. The fuel savings over this period more realistically represented the actual fuel savings that would be achieved through the use of the selected study options.

TABLE 78

COMPARATIVE FUEL CONSUMPTION (Millions of Tons)

Scenario Description & Fuel Price (¢/Gal)	Annual		Cumulative	
	1980	1990	1976-1990	1980-1990
Baseline @ 30¢	5.770	9.017	101.097	79.267
All Derivatives @ 30¢	5.723	8.062	96.699	74.869
Selected Derivatives @ 30¢	5.723	8.044	96.534	74.704
Selected Derivatives and N80's @ 30¢	5.714	8.031	96.560	74.730
Baseline @ 60¢	5.773	9.005	101.086	79.239
All Derivatives @ 60¢	5.733	8.043	96.648	74.801
Selected Derivatives @ 60¢	5.733	8.036	96.510	74.663
Selected Derivatives and N80's @ 60¢	5.723	7.971	96.108	74.261
N80's* + 70% L.F. @ 60¢	5.723	6.565	86.573	64.726
N80's* + 70% L.F. + Fuel Alloc. @ 60¢	4.980	5.042	75.033	54.865

*N80's = Derivatives + N80's

As expected, the baseline scenarios with fuel prices of 30 cents and 60 cents per gallon, and fleets consisting of only baseline aircraft types through 1990 demanded the most jet fuel, 101.1 million tons, over the study period, 1976-1990. The lowest fuel consumption, 86.6 million tons, was achieved by the mixed fleet of selected derivatives and new near-term aircraft performing at a 70 percent load factor in a non-fuel constrained scenario. In a static airline environment, the difference in fuel burned with the higher goal load factor was 18 percent or 1.4 million tons less in 1990 alone.

The potential for fuel savings with each succeeding fleet forecast based upon different offerings of aircraft options under both fuel environments is shown in Table 79 for the 1976-1990 forecast period, 1980-1990 time period, as well as in the year 1990. The results of the 30 cents scenarios were judged against those of the baseline scenario with fuel at 30 cents per gallon, while the results of the 60 cents scenarios were compared against those for the baseline scenario with fuel at 60 cents per gallon. The fuel consumed by the fuel constrained fleet during these time periods were compared with those achieved from a mixed fleet of selected options with a 70 percent goal load factor, and no fuel constraints. This comparison was made on the basis of pounds of fuel burned per RPM since the fuel constrained scenario did not perform all the RPM demand.

TABLE 79

COMPARATIVE FUEL SAVINGS PER RPM (PERCENT)

Scenario Description & Fuel Price (¢/Gal)	Annual	Cumulative	
	1990	1976-1990	1980-1990
Relative to Baseline Scenario with Fuel at 30¢ Per Gallon			
Selected Derivatives @ 30¢	10.8	4.5	5.8
Selected Derivatives and N80's @ 30¢	10.9	4.5	5.7
Relative to Baseline Scenario with Fuel at 60¢ Per Gallon			
Selected Derivatives @ 60¢	10.8	4.5	5.8
Selected Derivatives and N80's @ 60¢	11.5	4.9	6.3
N80's + 70% L.F. @ 60¢	27.1	14.4	18.3
Relative to N80's Scenario, 70% L.F., with Fuel at 60¢ Per Gallon			
N80's* + 70% L.F. + Fuel Alloc. @ 60¢	1.3	1.6	2.9

*N80's = Derivatives and N80's

When the selected derivative options were added to the fleet of existing airplanes, at either study fuel price, fuel savings improved substantially to almost 6 percent during 1980-1990 and almost 11 percent in 1990 alone, or a savings of over 4.6 million tons from 1980-1990. Fuel savings did not improve significantly with the addition of the selected new near-term options (N80's), as can be seen in the table.

When the goal load factor was increased from 58 percent to 70 percent in 1980, the fuel savings achieved with a market selected fleet of derivatives plus N80's at a fuel price of 60 cents per gallon were substantial. Fuel savings of 13 percent during 1980-1990 and 17 percent during 1990 alone were obtained above those savings already provided by the mixed fleet selected at the same fuel price but with the study load factor of 58 percent; again showing the strong impact of higher load factors on fuel efficiency.

Results for the fleet forecast under a fuel allocated environment and a 70 percent load factor were very similar to those for the unconstrained fuel scenario at the same load factor. The fuel constrained fleet obtained savings of 16 percent during 1976-1990 and 21 percent during 1980-1990 over the baseline 60 cent scenario. These percentages are slightly higher, 2.9 percent in 1980-1990 and 1.6 percent during 1976-1990, than for the unconstrained fuel scenario due to the higher fuel efficiency produced by the fuel constrained fleet.

4.9 Conclusions

From this study, the most important conclusions that can be drawn about the relative importance of each of the fuel saving options in reducing the fuel consumption of the U.S. international scheduled carriers during 1974-1990 are:

- Substantial fuel savings could be obtained operationally through the development and implementation of an improved ATC system.
- Higher load factors would improve fuel efficiency substantially in a static airline environment.
- Derivatives of current airplanes, sized to meet the future needs of the U.S. international market, would offer significant fuel savings as well as improved economics over the current baseline aircraft.
- A 400-seat aircraft would be too big for the revenue passenger mile growth (4.6 percent per year) forecasted in the study market through at least 1985.
- The all-new (1980) international aircraft did not offer the potential for fuel savings that the domestic N80's did during the same study period.
- Therefore, the derivative aircraft were the most promising options for the U.S. international market in terms of fuel conservation as well as economic viability through 1990.

SECTION 5.0

TURBOPROP ECONOMICS

As part of the RECAT follow-on study, two short/medium range turboprop configurations were designed to take advantage of recent advances in turboprop technology. These DC-9/B-737 type replacement aircraft were then operationally and economically compared with current or modified turbofan airplanes.

The two turboprop designs used the basic DC-9-30 fuselage configured for 92 seats. This seating capacity was consistent with the technical groundrule of a 10/90 split between first class and coach seats used in the domestic RECAT study. One turboprop (designated the DC-9-30D5) retained the conventional wing on the baseline DC-9-30 while the other (designated the DC-9-30D6) incorporated a supercritical wing. The DC-9-30D5 was compared with the baseline DC-9-30 turbofan while the DC-9-30D6 was compared to a DC-9-30 with a supercritical wing, designated the DC-9-30D4. The performance capabilities of both the turboprops and turbofans are documented in Section 6.0 of Volume I, Technical Analysis.

5.1 Aircraft Pricing

In order to realistically evaluate the economic viability of the turboprops, consistent aircraft prices and operating costs had to be developed. All aircraft prices were estimated in 1976 dollars, and then deescalated at 5 percent per year to 1973 dollars.

5.1.1 Airframe Prices

The 1976 airframe price for the baseline DC-9-30 was used for all the study airplanes since all four aircraft were designed for the same operating-payload capacity and their configurations differed only in powerplant type and arrangement and in wing planform geometry. Also the small differences in airframe cost weights, ± 2 percent, did not justify any differences in airframe cost.

5.1.2 Engine Prices

The price of the JT8D-11 engine used on both turbofans were derived from the engine manufacturer's estimate of the 1976 price. For the turboprop airplanes, Hamilton-Standard provided estimates of the propfan and gearbox in 1976 dollars. These estimates were based on a market size of 400 aircraft over a five year period. They also estimated that the price of the Pratt & Whitney STS-476 engine would be about 86 percent of the price of the advanced technology ten-ton engine, the JT10D-2, in 1976 dollars. Therefore, the total turboshaft engine package in 1973 dollars was priced at $1.86 million.

5.1.3 Comparative Aircraft Prices

Based on these assumptions, the total aircraft prices were developed and are given in Table 80. The turboprop airplanes have a total flyaway cost estimated to be 12 percent higher than for the turbofan aircraft.

TABLE 80

COMPARATIVE AIRCRAFT PRICES
(Millions of 1973 Dollars)

Price Components	DC-9-30 Baseline	DC-9-30D4 Turbofan-SCW	DC-9-30D5 Propfan	DC-9-30D6 Propfan-SCW
Airframe	$4.48	$4.48	$4.48	$4.48
Engines	1.20	1.20	1.47	1.47
Gearboxes & Propfans	--	--	.39	.39
Total Aircraft Price	$5.68	$5.68	$6.34	$6.34

5.2 Direct Operating Costs

The direct operating costs for the four study airplanes were calculated using the 1967 ATA DOC method updated to 1973 cost levels. This procedure was also used in the domestic RECAT study and allows a reasonable and consistent economic comparison of various aircraft types. The assumptions used in determining DOC's are listed in Figure 73. These assumptions were the same for both the turbofan and turboprop aircraft. Possible maintenance expense benefits with the turboprop aircraft from reductions in the maintenance of brakes, tires, and wheels had not yet been documented. Also, possible turboprop gearbox maintenance cost penalties have not been determined. Therefore, the maintenance equations given in Section 2.5, Page 39, were used for both aircraft types.

- o MODIFIED 1967 ATA DOC EQUATIONS (SEC. 2.5, FIG. 15)
- o CREW COSTS - 1967 ATA EQUATION ESCALATED AT 6% PER YEAR
- o FUEL PRICES - 30¢ AND 60¢ PER GALLON
- o ANNUAL UTILIZATION - 3,000 HOURS
- o INSURANCE RATE - 1%
- o DEPRECIATION - 16 YEARS, 10% RESIDUAL
- o SPARES - 15% TOTAL FLYAWAY COST
- o LABOR RATE - $6.10 PER YEAR
- o MAINTENANCE BURDEN - 1.8 X DIRECT AIRFRAME AND ENGINE LABOR COST

Figure 73. DIRECT OPERATING COST ASSUMPTIONS - 1973 DOLLARS

The DOC's for the study aircraft were calculated at various stage lengths using the two NASA-specified fuel prices of 30 cents and 60 cents per gallon. The calculated DOC's were tabulated in terms of dollars per block hour ($/HR), dollars per nautical mile ($/NM), and cents per available seat-nautical mile (¢/ASNM). This information is presented in Table 81 using a fuel price of 30 cents per gallon and in Table 82 at 60 cents per gallon. Although the turboprop airplanes appear to be slightly more expensive initially than comparable turbofans, due to fuel savings of between 27 and 33 percent, the turboprops offered DOC savings of 5-6 percent with fuel at 30 cents per gallon and 9-10 percent at 60 cents per gallon, as shown in Table 83. Maintenance benefits could increase these savings slightly.

Table 83 also shows the DOC benefits derived from the incorporation of a supercritical wing on a turboprop. However, it should be noted that in pricing the turboprops, it was assumed that the nonrecurring development costs of the supercritical wing had been absorbed by prior funding from government and industry research, technology, and development programs. Under this assumption the actual cost of manufacturing and installing a supercritical wing

TABLE 81

COMPARATIVE DIRECT OPERATING COSTS - 1973 DOLLARS

FUEL PRICE = 30c PER GALLON

STAGE LENGTH (NM)	DC-9-30 Baseline			DC-9-30D4 (TF, SCW)			DC-9-30D5 (TP, CW)			DC-9-30D6 (TP, SCW)		
	$/HR	$/NM	¢/ASNM	$/HR	$/NM	¢/ASNM	$/HR	$/NM	¢/ASNM	$/HR	$/NM	¢/ASNM
100	719.23	4.03	4.38	715.94	4.01	4.36	702.69	3.79	4.12	699.69	3.78	4.11
250	702.96	2.47	2.69	691.86	2.44	2.65	680.07	2.34	2.54	671.48	2.31	2.51
500	688.96	1.94	2.11	672.14	1.90	2.06	661.36	1.84	2.00	648.87	1.80	1.96
750	685.13	1.77	1.93	664.00	1.72	1.87	653.83	1.67	1.82	639.19	1.64	1.78
1,000	681.90	1.69	1.84	659.19	1.63	1.78	650.15	1.59	1.73	634.02	1.55	1.69
1,250	680.97	1.64	1.78	657.00	1.58	1.72	648.34	1.55	1.68	631.00	1.50	1.64
1,320	680.66	1.63	1.77	-	-	-	-	-	-	-	-	-
1,410	-	-	-	656.69	1.56	1.69	-	-	-	-	-	-
1,500	-	-	-	-	-	-	647.54	1.52	1.65	629.14	1.47	1.60
1,860	-	-	-	-	-	-	647.40	1.49	1.62	-	-	-
1,980	-	-	-	-	-	-	-	-	-	627.22	1.44	1.56
290-30,000'	701.02	2.32	2.52	688.61	2.28	2.48	676.87	2.19	2.38	667.34	2.16	2.35
290-15,000'	739.52	2.50	2.72	727.50	2.46	2.67	705.50	2.34	2.54	694.15	2.32	2.52

TABLE 82

COMPARATIVE DIRECT OPERATING COSTS - 1973 DOLLARS

FUEL PRICE = 60¢ PER GALLON

STAGE LENGTH (NM)	DC-9-30 Baseline			DC-9-30D4 (TF, SCW)			DC-9-30D5 (TP, CW)			DC-9-30D6 (TP, SCW)		
	$/HR	$/NM	¢/ASNM	$/HR	$/NM	¢/ASNM	$/HR	$/NM	¢/ASNM	$/HR	$/NM	¢/ASNM
100	975.49	5.46	5.94	968.61	5.42	5.90	909.07	4.91	5.34	902.76	4.87	5.30
250	967.34	3.41	3.70	944.95	3.33	3.62	892.55	3.07	3.34	875.15	3.01	3.27
500	955.40	2.69	2.93	921.61	2.60	2.82	873.62	2.43	2.64	848.49	2.36	2.56
750	955.01	2.47	2.69	912.64	2.36	2.57	866.82	2.22	2.41	837.44	2.14	2.33
1,000	952.76	2.36	2.57	907.27	2.25	2.45	864.17	2.12	2.30	831.82	2.04	2.22
1,250	953.57	2.30	2.50	905.56	2.18	2.37	863.57	2.06	2.24	828.81	1.98	2.15
1,320	953.54	2.28	2.48	-	-	-	-	-	-	-	-	-
1,410	-	-	-	906.17	2.15	2.33	-	-	-	-	-	-
1,500	-	-	-	-	-	-	864.07	2.02	2.20	827.21	1.94	2.10
1,860	-	-	-	-	-	-	865.92	1.99	2.16	-	-	-
1,980	-	-	-	-	-	-	-	-	-	826.05	1.89	2.05
290-30,000'	967.01	3.20	3.48	942.01	3.12	3.39	890.27	2.89	3.14	871.02	2.82	3.07
290-15,000'	1044.82	3.53	3.84	1020.60	3.45	3.75	948.46	3.14	3.41	926.01	3.10	3.37

should be equivalent to that for a conventional wing. However, if the manufacturer has to absorb the costs of the new technology development, the DOC savings with the turboprops could be considerably reduced. Therefore, the benefits from and the costs of supercritical wing technology when applied to turboprop aircraft must be studied further before these preliminary DOC savings can be validated.

TABLE 83

DOC SAVINGS OF TURBOPROP AIRCRAFT RELATIVE TO COMPARABLE TURBOFANS

Aircraft Comparisons	CAB Average Stage Length (290 NM)		1,000 NM	
	30¢/Gal	60¢/Gal	30¢/Gal	60¢/Gal
DC-9-30D5 Propfan vs. DC-9-30 Turbofan	5.5	9.9	5.8	10.4
DC-9-30D6 Propfan (SCW) vs. DC-9-30D4 Turbofan (SCW)	5.1	9.5	5.0	9.4
DC-9-30D6 Propfan (SCW) vs. DC-9-30D5 Propfan	1.4	2.2	2.5	3.7

The effect of cruise altitude on DOC was also analyzed at the CAB average stage length for the DC-9-30 in 1973. Each airplane was flown over this 290 nautical mile stage length at cruise altitudes of 15,000 feet and 30,000 feet. When the cruise altitude was reduced for the same stage length, the fuel consumed by all the study airplanes was much higher. Consequently, not only was fuel cost a greater portion of DOC, but total DOC's increased significantly for each airplane (Table 84). With the lower cruise altitude of 15,000 feet, DOC savings from turboprop aircraft compared to turbofans increased slightly as shown in Table 85.

TABLE 84

EFFECT OF REDUCING CRUISE ALTITUDE FROM 30,000 FT TO 15,000 FT
(290 Nautical Mile Stage Length)

FUEL PRICES OF 30¢ and 60¢ PER GALLON

Aircraft Type	Fuel Burned (% Increase)	DOC (% Increase)		Fuel Cost as Percent of Total DOC			
				30,000 Ft		15,000 Ft	
		30¢	60¢	30¢	60¢	30¢	60¢
DC-9-30	17.2	7.7	10.3	37.9	55.0	41.3	58.4
DC-9-30D4	18.1	7.8	10.6	36.8	53.8	40.3	57.4
DC-9-30D5	16.3	6.4	8.8	31.5	47.9	34.4	51.2
DC-9-30D6	17.5	7.3	9.7	30.5	46.8	33.4	50.1

TABLE 85

DOC SAVINGS OF TURBOPROP AIRCRAFT RELATIVE TO
COMPARABLE TURBOFANS
Cruise Altitude = 15,000 Ft

Aircraft Comparisons	CAB Average Stage Length (290 NM)	
	30¢/Gal	60¢/Gal
DC-9-30D5 Turboprop vs. DC-9-30 Turbofan	6.5	11.1
DC-9-30D6 Turboprop (SCW) vs. DC-9-30D4 Turbofan (SCW)	5.6	10.2

5.3 Conclusions

This preliminary investigation indicates considerable promise as to the economic viability of advanced technology turboprops in competition with current and derivative turbofan aircraft in the air transportation system. With fuel savings of approximately 27-33 percent and DOC reductions of over 5 percent with fuel at 30 cents per gallon or 10 percent at 60 cents per gallon, a turboprop replacement for the current DC-9/B737 aircraft types most definitely warrants more extensive research and analysis.

SECTION 6.0 RECOMMENDED FUTURE WORK

- Expand the study of fuel-conservative flight operations to include all aircraft types in the domestic fleet, and a wider scope of operational variations. The study results should be specific to each airline's market, fleet, and schedule.

- Develop methodology to effectively evaluate, from an airline's viewpoint, the economic potential of retrofitting current generation aircraft to conserve fuel.

- Evaluate the potential fuel savings benefits accruing from an improved air traffic control system weighed against the total costs of improving the system.

- Investigate the potential fuel savings benefits of reducing fuel reserve requirements for the U.S. air transportation system under an improved ATC system.

- Examine the effect of striving for higher load factors, as a means to reduce aircraft fuel consumption, on forecasted market demand and service frequencies.

- An in-depth study of traffic demand, jet fuel prices, and fare levels, as well as their interreactions, to estimate the future elasticity of air travel demand in the U.S. domestic air transportation system.

- Evaluate the fuel conserving potential and applicability of a smaller N80 airplane (125-150 seats) with a design range of 1500 nautical miles for the U.S. domestic air transportation system.

- Size and design an all-new aircraft specifically for the operations of the U.S. international carriers optimizing the designs for minimum DOC's at several fuel prices and minimum fuel consumption. Assess the fuel saving potential and economic viability of this airplane family in simulated international operations. The sizing of this airplane should begin with a seating capacity of approximately 150-175 seats and a design range of 5000-5500 nautical miles.

- Expand the study of DC-9 turboprop aircraft to examine the benefits from and costs of other advanced technologies when applied to this type of airplane.

- Conduct a comparative market and economic analysis to determine the operational and economic performance of turboprop aircraft versus comparable turbofan aircraft over the same selected airline network.

SECTION 7.0

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APPENDIX

TABLE A-1

DC-8-21 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	175	958.81	5.47	3.74	2318.03	13.21	9.05
250	283	907.16	3.19	2.19	1654.73	5.82	3.99
500	358	899.95	2.52	1.73	1202.83	3.37	2.31
750	393	898.43	2.29	1.57	999.57	2.55	1.74
1,000	413	897.55	2.17	1.49	881.98	2.13	1.46
2,000	447	895.29	2.00	1.37	679.60	1.52	1.04
3,000	460	894.44	1.94	1.33	604.48	1.31	.90
AVG. STAGE	402	897.74	2.23	1.53	939.47	2.33	1.60

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,210,000

FUEL COST = 15¢/GALLON

TABLE A-2

DC-8-21 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi. **	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1178.76	6.72	4.60			
250		1141.09	4.02	2.75			
500		1171.48	3.28	2.25			
750		1188.70	3.03	2.07			
1,000		1198.66	2.90	1.99			
2,000		1214.25	2.71	1.86			
3,000		1220.04	2.65	1.82			
AVG. STAGE		1193.29	2.96	2.03			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$7,210,000

FUEL COST = 30¢/GALLON

TABLE A-3

DC-8-21 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1618.67	9.23	6.32			
250		1608.95	5.66	3.88			
500		1714.55	4.80	3.29			
750		1769.24	4.51	3.09			
1,000		1800.88	4.36	2.99			
2,000		1852.19	4.14	2.84			
3,000		1871.23	4.07	2.79			
AVG. STAGE		1784.40	4.43	3.03			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,210,000

FUEL COST = 60¢/GALLON

TABLE A-4

DC-8-21 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.825	.509	.405	.368	.350	.323	.314	.359
INSURANCE	.104	.064	.051	.047	.044	.041	.040	.046
DEPRECIATION	.684	.423	.336	.306	.291	.268	.261	.298
MAINTENANCE:								
AIRFRAME	.850	.387	.234	.182	.156	.117	.104	.168
ENGINE	.422	.240	.179	.158	.148	.133	.128	.153
FUEL @ 15¢/GAL	.859	.564	.521	.506	.499	.488	.485	.503
TOTAL DOC	3.744	2.187	1.726	1.567	1.488	1.370	1.332	1.527
FUEL @ 30¢/GAL	1.717	1.128	1.042	1.012	.998	.977	.969	1.005
TOTAL DOC	4.602	2.751	2.247	2.073	1.987	1.859	1.816	2.029
FUEL @ 60¢/GAL	3.435	2.256	2.083	2.025	1.996	1.953	1.939	2.010
TOTAL DOC	6.320	3.879	3.289	3.086	2.985	2.835	2.786	3.034

TABLE A-5

DC-8-52 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	189	1019.10	5.40	3.70	2545.50	13.49	9.24
250	295	953.27	3.24	2.22	1749.53	5.95	4.07
500	362	903.21	2.49	1.71	1243.19	3.43	2.35
750	392	881.12	2.24	1.54	1017.86	2.59	1.78
1,000	409	867.47	2.13	1.46	887.84	2.18	1.49
2,000	437	846.55	1.94	1.33	675.07	1.55	1.06
3,000	447	838.91	1.88	1.29	597.38	1.34	.91
AVG. STAGE	390	882.32	2.26	1.55	1030.38	2.64	1.81

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $8,600,000

FUEL COST = 15¢/GALLON

TABLE A-6

DC-8-52 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1238.76	6.57	4.50			
250		1187.92	4.03	2.76			
500		1139.44	3.14	2.15			
750		1118.16	2.85	1.95			
1,000		1104.02	2.70	1.85			
2,000		1083.81	2.48	1.70			
3,000		1076.43	2.41	1.65			
AVG. STAGE		1119.29	2.86	1.96			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $8,600,000

FUEL COST = 30¢/GALLON

TABLE A-7

DC-8-52 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1678.07	8.89	6.09			
250		1657.20	5.63	3.85			
500		1611.89	4.45	3.05			
750		1592.25	4.05	2.78			
1,000		1577.11	3.86	2.65			
2,000		1558.33	3.57	2.44			
3,000		1551.47	3.47	2.38			
AVG. STAGE		1593.22	4.08	2.79			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $8,600,000

FUEL COST = 60¢/GALLON

TABLE A-8

DC-8-52 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.773	.495	.402	.371	.357	.334	.326	.373
INSURANCE	.104	.067	.054	.050	.048	.045	.044	.050
DEPRECIATION	.683	.438	.355	.328	.316	.295	.288	.330
MAINTENANCE:								
AIRFRAME	.883	.403	.244	.190	.164	.124	.111	.193
ENGINE	.459	.269	.205	.184	.174	.158	.152	.185
FUEL @ 15¢/GAL	.797	.546	.447	.414	.397	.372	.364	.415
TOTAL DOC	3.699	2.218	1.707	1.537	1.456	1.328	1.285	1.546
FUEL @ 30¢/GAL	1.595	1.092	.893	.827	.794	.744	.728	.830
TOTAL DOC	4.497	2.764	2.154	1.950	1.853	1.700	1.649	1.961
FUEL @ 60¢/GAL	3.190	2.183	1.786	1.654	1.588	1.489	1.456	1.661
TOTAL DOC	6.092	3.855	3.047	2.777	2.647	2.445	2.377	2.792

TABLE A-9

DC-8-61 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi. **	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi. **
100	169	1099.71	6.49	3.20	2871.86	16.94	8.35
250	281	1023.33	3.64	1.79	2095.85	7.46	3.68
500	357	965.10	2.70	1.33	1538.06	4.31	2.12
750	387	935.69	2.42	1.19	1263.53	3.27	1.61
1,000	405	923,05	2.28	1.12	1111.88	2.75	1.35
2,000	435	909.18	2.09	1.03	854.76	1.97	.97
3,000	448	911.95	2.04	1.00	762.70	1.70	.84
AVG. STAGE	392	934.24	2.38	1.17	1229.61	3.14	1.55

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,300,000

FUEL COST = 15¢/GALLON

TABLE A-10

DC-8-61 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1354.85	7.99	3.94			
250		1280.95	4.56	2.25			
500		1220.97	3.42	1.68			
750		1189.57	3.08	1.52			
1,000		1179.56	2.91	1.44			
2,000		1177.69	2.71	1.33			
3,000		1192.64	2.66	1.31			
AVG. STAGE		1190.17	3.04	1.50			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,300,000

FUEL COST = 30¢/GALLON

TABLE A-11

DC-8-61 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1865.15	11.00	5.42			
250		1796.17	6.39	3.15			
500		1732.69	4.85	2.39			
750		1697.34	4.39	2.16			
1,000		1692.58	4.18	2.06			
2,000		1714.71	3.94	1.94			
3,000		1754.01	3.92	1.93			
AVG. STAGE		1702.02	4.34	2.14			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,300,000

FUEL COST = 60¢/GALLON

TABLE A-12

DC-8-61 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.624	.376	.296	.274	.261	.243	.236	.270
INSURANCE	.091	.055	.043	.040	.038	.036	.034	.039
DEPRECIATION	.598	.361	.284	.262	.251	.233	.226	.258
MAINTENANCE:								
AIRFRAME	.783	.350	.206	.159	.135	.100	.088	.153
ENGINE	.359	.201	.149	.134	.126	.114	.110	.132
FUEL @ 15¢/GAL	.741	.452	.353	.323	.312	.304	.309	.322
TOTAL DOC	3.196	1.795	1.331	1.192	1.123	1.030	1.003	1.174
FUEL @ 30¢/GAL	1.483	.903	.706	.647	.624	.608	.618	.643
TOTAL DOC	3.938	2.246	1.684	1.516	1.435	1.334	1.312	1.495
FUEL @ 60¢/GAL	2.966	1.807	1.412	1.294	1.248	1.217	1.236	1.286
TOTAL DOC	5.421	3.150	2.390	2.163	2.059	1.943	1.930	2.138

TABLE A-13

DC-9-15 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100	185	508.03	2.74	3.92	1068.02	5.77	8.24
250	291	501.25	1.72	2.46	747.09	2.57	3.67
500	352	491.36	1.40	1.99	531.80	1.51	2.16
750	381	486.55	1.28	1.83	439.83	1.16	1.65
1,000	400	486.14	1.22	1.74	390.20	.98	1.39
1,250	401	486.88	1.19	1.70	355.74	.87	1.24
1,500	417	489.00	1.17	1.68	333.16	.80	1.14
AVG. STAGE	309	497.83	1.61	2.30	685.30	2.22	3.17

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 70

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $4,100,000

FUEL COST = 15¢/GALLON

TABLE A-14

DC-9-15 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		607.74	3.28	4.69			
250		610.59	2.10	3.00			
500		601.72	1.71	2.44			
750		596.79	1.57	2.24			
1,000		598.53	1.50	2.14			
1,250		601.75	1.47	2.10			
1,500		607.16	1.46	2.08			
AVG. STAGE		606.89	1.96	2.80			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 70

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $4,100,000

FUEL COST = 30¢/GALLON

TABLE A-15

DC-9-15 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		807.16	4.36	6.23			
250		829.26	2.85	4.08			
500		822.45	2.34	3.34			
750		817.26	2.15	3.07			
1,000		823.31	2.06	2.94			
1,250		831.48	2.04	2.91			
1,500		843.48	2.02	2.89			
AVG. STAGE		825.00	2.67	3.81			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 70

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $4,100,000

FUEL COST = 60¢/GALLON

TABLE A-16

DC-9-15 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	1.144	.729	.602	.557	.530	.519	.509	.685
INSURANCE	.124	.079	.065	.060	.057	.056	.055	.074
DEPRECIATION	.814	.519	.428	.396	.377	.369	.362	.487
MAINTENANCE:								
AIRFRAME	.582	.317	.233	.204	.188	.180	.174	.289
ENGINE	.486	.282	.218	.195	.183	.177	.172	.260
FUEL @ 15¢/GAL	.769	.537	.448	.414	.401	.402	.405	.504
TOTAL DOC	3.919	2.463	1.994	1.826	1.736	1.703	1.677	2.299
FUEL @ 30¢/GAL	1.538	1.075	.896	.827	.803	.803	.810	1.008
TOTAL DOC	4.688	3.001	2.442	2.239	2.138	2.104	2.082	2.803
FUEL @ 60¢/GAL	3.077	2.149	1.791	1.655	1.606	1.607	1.620	2.015
TOTAL DOC	6.227	4.075	3.337	3.067	2.941	2.908	2.892	3.810

TABLE A-17

DC-9-32 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	182	542.90	2.99	3.25	1305.30	7.18	7.80
250	286	528.46	1.86	2.02	914.45	3.22	3.50
500	355	518.00	1.46	1.59	670.87	1.89	2.06
750	381	510.60	1.34	1.46	554.27	1.46	1.58
1,000	397	507.44	1.28	1.39	490.62	1.24	1.34
1,250	408	506.56	1.24	1.35	450.75	1.10	1.20
1,500	417	507.44	1.22	1.32	422.92	1.02	1.10
AVG. STAGE	302	527.46	1.75	1.90	861.02	2.85	3.10

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,150,000

FUEL COST = 15¢/GALLON

TABLE A-18

DC-9-32 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		644.99	3.55	3.86			
250		640.40	2.25	2.45			
500		634.71	1.79	1.95			
750		627.09	1.65	1.79			
1,000		624.71	1.57	1.71			
1,250		625.46	1.53	1.66			
1,500		628.95	1.51	1.64			
AVG. STAGE		641.78	2.12	2.31			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,150,000

FUEL COST = 30¢/Gallon

TABLE A-19

DC-9-32 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		849.17	4.67	5.08			
250		864.28	3.04	3.31			
500		868.11	2.45	2.66			
750		860.06	2.26	2.46			
1,000		859.25	2.17	2.35			
1,250		863.24	2.11	2.30			
1,500		871.97	2.09	2.27			
AVG. STAGE		870.42	2.88	3.13			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,150,000

FUEL COST = 60¢/Gallon

TABLE A-20

DC-9-32 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	.894	.572	.458	.427	.410	.398	.390	.538
INSURANCE	.103	.066	.053	.049	.047	.046	.045	.062
DEPRECIATION	.674	.431	.345	.322	.309	.300	.294	.406
MAINTENANCE:								
AIRFRAME	.590	.306	.209	.179	.163	.153	.147	.278
ENGINE	.375	.219	.165	.148	.140	.135	.131	.203
FUEL @ 15¢/GAL	.610	.428	.358	.333	.321	.316	.317	.411
TOTAL DOC	3.246	2.022	1.588	1.458	1.390	1.348	1.324	1.898
FUEL @ 30¢/GAL	1.220	.856	.716	.665	.642	.632	.634	.822
TOTAL DOC	3.856	2.450	1.946	1.790	1.711	1.664	1.641	2.309
FUEL @ 60¢/GAL,	2.441	1.713	1.431	1.330	1.285	1.265	1.268	1.645
TOTAL DOC	5.077	3.307	2.661	2.455	2.354	2.297	2.275	3.132

TABLE A-21

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100	164	1512.33	9.23	3.33	3955.25	24.13	8.71
250	275	1386.55	5.05	1.82	2903.02	10.57	3.82
500	355	1295.85	3.65	1.32	2144.31	6.05	2.18
750	389	1256.28	3.23	1.17	1769.20	4.55	1.64
1,000	408	1231.68	3.02	1.09	1553.22	3.81	1.37
2,000	445	1200.83	2.70	.97	1192.33	2.68	.97
3,000	459	1197.69	2.61	.94	1057.38	2.30	.83
AVG. STAGE	399	1241.61	3.11	1.12	1652.37	4.14	1.49

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $18,300,000

FUEL COST = 15¢/GALLON

TABLE A-22

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1817.39	11.09	4.00			
250		1691.49	6.16	2.22			
500		1600.71	4.51	1.63			
750		1566.00	4.03	1.46			
1,000		1542.37	3.78	1.36			
2,000		1523.79	3.42	1.24			
3,000		1533.68	3.34	1.21			
AVG. STAGE		1550.47	3.89	1.40			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$18,300,000

FUEL COST = 30¢/GALLON

TABLE A-23

DC-10-10 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2427.52	14.81	5.35			
250		2301.38	8.38	3.02			
500		2210.43	6.23	2.25			
750		2185.44	5.62	2.03			
1,000		2163.76	5.30	1.91			
2,000		2169.70	4.87	1.76			
3,000		2205.66	4.80	1.73			
AVG. STAGE		2168.20	5.43	1.96			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $18,300,000

FUEL COST = 60¢/GALLON

TABLE A-24

DC-10-10 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.489	.292	.226	.206	.196	.180	.175	.201
INSURANCE	.122	.073	.057	.052	.049	.045	.044	.050
DEPRECIATION	.805	.480	.372	.339	.323	.296	.287	.331
MAINTENANCE:								
AIRFRAME	.972	.423	.241	.180	.150	.104	.089	.164
ENGINE	.270	.153	.113	.102	.096	.086	.082	.098
FUEL @ 15¢/GAL	.672	.401	.310	.288	.275	.262	.264	.279
TOTAL DOC	3.330	1.822	1.319	1.167	1.089	.973	.941	1.123
FUEL @ 30¢/GAL	1.344	.802	.621	.576	.550	.524	.528	.559
TOTAL DOC	4.002	2.223	1.630	1.455	1.364	1.235	1.205	1.403
FUEL @ 60¢/GAL	2.687	1.603	1.241	1.151	1.100	1.047	1.056	1.117
TOTAL DOC	5.345	3.024	2.250	2.030	1.914	1.758	1.733	1.961

TABLE A-25

DC-10-40 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	1720.77	10.50	4.17	4083.61	24.91	9.89
250	275	1570.27	5.72	2.27	2975.18	10.83	4.30
500	355	1461.74	4.12	1.64	2175.96	6.14	2.44
750	389	1414.83	3.64	1.44	1781.35	4.58	1.82
1,000	408	1383.27	3.39	1.34	1554.01	3.81	1.51
2,000	445	1346.72	3.02	1.20	1174.03	2.64	1.05
3,000	459	1342.44	2.92	1.16	1031.96	2.25	.89
AVG. STAGE	381	1425.62	3.74	1.49	1885.20	4.95	1.97

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $21,500,000

FUEL COST = 15¢/GALLON

TABLE A-26

DC-10-40 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		2083.90	12.71	5.04			
250		1923.06	7.00	2.78			
500		1807.09	5.10	2.02			
750		1762.83	4.54	1.80			
1,000		1728.23	4.23	1.68			
2,000		1703.23	3.82	1.52			
3,000		1712.71	3.73	1.48			
AVG. STAGE		1771.43	4.65	1.85			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $21,500,000

FUEL COST = 30¢/GALLON

TABLE A-27

DC-10-40 BASELINE

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2810.16	17.14	6.80			
250		2628.65	9.57	3.80			
500		2497.79	7.04	2.80			
750		2458.84	6.33	2.51			
1,000		2418.14	5.92	2.35			
2,000		2416.26	5.42	2.15			
3,000		2453.27	5.34	2.12			
AVG. STAGE		2463.04	6.47	2.57			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$21,500,000

FUEL COST = 60¢/GALLON

TABLE A-28

DC-10-40 BASELINE - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.559	.334	.258	.236	.224	.206	.200	.241
INSURANCE	.158	.095	.073	.067	.064	.058	.056	.068
DEPRECIATION	1.040	.620	.481	.439	.418	.383	.371	.448
MAINTENANCE:								
AIRFRAME	1.186	.515	.291	.218	.181	.125	.107	.235
ENGINE	.343	.195	.146	.130	.123	.110	.106	.134
FUEL @ 15¢/GAL	.879	.510	.387	.355	.335	.318	.320	.360
TOTAL DOC	4.165	2.269	1.636	1.445	1.345	1.200	1.160	1.486
FUEL @ 30¢/GAL	1.758	1.019	.773	.710	.670	.635	.640	.720
TOTAL DOC	5.044	2.778	2.022	1.800	1.680	1.517	1.480	1.846
FUEL @ 60¢/GAL	3.516	2.038	1.546	1.421	1.341	1.271	1.279	1.442
TOTAL DOC	6.802	3.797	2.795	2.511	2.351	2.152	2.119	2.568

TABLE A-29

DC-8-20R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	175	1218.51	6.95	4.76	2318.03	13.21	9.05
250	283	1152.82	4.06	2.78	1654.73	5.82	3.99
500	358	1107.39	3.10	2.12	1202.83	3.37	2.31
750	393	1087.99	2.77	1.90	999.57	2.55	1.74
1,000	413	1076.77	2.61	1.78	881.98	2.13	1.46
2,000	447	1057.00	2.36	1.62	679.60	1.52	1.04
3,000	460	1049.67	2.28	1.56	604.48	1.31	.90
AVG. STAGE	402	1082.12	2.69	1.84	939.47	2.33	1.60

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,350,000

FUEL COST = 15¢/Gallon

TABLE A-30

DC-8-20R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1425.32	8.12	5.57			
250		1361.91	4.79	3.28			
500		1317.56	3.69	2.53			
750		1299.74	3.31	2.27			
1,000		1289.43	3.12	2.14			
2,000		1270.77	2.84	1.95			
3,000		1263.85	2.75	1.88			
AVG. STAGE		1294.19	3.21	2.20			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,350,000

FUEL COST = 30¢/Gallon

TABLE A-31

DC-8-20R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1838.89	10.48	7.18			
250		1780.11	6.27	4.29			
500		1737.88	4.87	3.33			
750		1723.24	4.39	3.01			
1,000		1714.77	4.15	2.84			
2,000		1698.31	3.80	2.60			
3,000		1692.20	3.68	2.52			
AVG. STAGE		1718.32	4.27	2.92			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,350,000

FUEL COST = 60¢/Gallon

TABLE A-32

DC-8-20R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.825	.509	.405	.368	.350	.323	.314	.359
INSURANCE	.077	.048	.038	.035	.033	.031	.030	.034
DEPRECIATION	1.624	1.003	.798	.726	.689	.637	.620	.707
MAINTENANCE:								
AIRFRAME	.850	.387	.234	.182	.156	.117	.104	.168
ENGINE	.574	.328	.246	.218	.204	.183	.176	.211
FUEL @ 15¢/GAL	.807	.504	.403	.369	.352	.327	.319	.361
TOTAL DOC	4.757	2.779	2.124	1.898	1.784	1.618	1.563	1.840
FUEL @ 30¢/GAL	1.615	1.008	.806	.739	.705	.654	.637	.721
TOTAL DOC	5.565	3.283	2.527	2.267	2.137	1.945	1.881	2.200
FUEL @ 60¢/GAL	3.229	2.017	1.612	1.478	1.410	1.309	1.275	1.443
TOTAL DOC	7.179	4.292	3.333	3.006	2.842	2.600	2.519	2.922

TABLE A-33

DC-8-20DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	175	879.74	5.01	3.44	2318.03	13.21	9.05
250	283	826.25	2.91	1.99	1654.73	5.82	3.99
500	358	813.17	2.28	1.56	1202.83	3.37	2.31
750	393	808.92	2.06	1.41	999.57	2.55	1.74
1,000	413	806.46	1.95	1.34	881.98	2.13	1.46
2,000	447	801.51	1.79	1.23	679.60	1.52	1.04
3,000	460	799.68	1.74	1.19	604.48	1.31	.90
AVG. STAGE	402	807.43	2.00	1.37	939.47	2.33	1.60

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $1,534,000

FUEL COST = 15¢/Gallon

TABLE A-34

DC-8-20DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1097.58	6.26	4.29			
250		1056.20	3.72	2.55			
500		1074.89	3.01	2.06			
750		1086.63	2.77	1.90			
1,000		1093.43	2.65	1.81			
2,000		1103.66	2.47	1.69			
3,000		1107.46	2.41	1.65			
AVG. STAGE		1089.64	2.71	1.85			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $1,534,000

FUEL COST = 30¢/Gallon

TABLE A-35

DC-8-20DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC			TOTAL IOC		
		$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1533.25	8.74	5.99			
250		1516.13	5.34	3.66			
500		1598.32	4.48	3.07			
750		1642.07	4.18	2.86			
1,000		1667.38	4.04	2.76			
2,000		1707.96	3.82	2.61			
3,000		1723.03	3.74	2.57			
AVG. STAGE		1654.05	4.11	2.81			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $1,534,000

FUEL COST = 60¢/Gallon

TABLE A-36

DC-8-20DR - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.825	.509	.405	.368	.350	.323	.314	.359
INSURANCE	.022	.014	.011	.010	.009	.008	.008	.010
DEPRECIATION	.465	.288	.229	.208	.198	.183	.178	.203
MAINTENANCE:								
AIRFRAME	.850	.387	.234	.182	.156	.117	.104	.168
ENGINE	.422	.240	.179	.158	.148	.133	.128	.153
FUEL @ 15¢/GAL	.851	.554	.502	.485	.476	.463	.458	.480
TOTAL DOC	3.435	1.992	1.560	1.411	1.337	1.227	1.190	1.373
FUEL @ 30¢/GAL	1.701	1.109	1.004	.969	.951	.925	.916	.960
TOTAL DOC	4.285	2.547	2.062	1.895	1.812	1.689	1.648	1.853
FUEL @ 60¢/GAL	3.402	2.217	2.007	1.938	1.903	1.850	1.833	1.920
TOTAL DOC	5.986	3.655	3.065	2.864	2.764	2.614	2.565	2.813

TABLE A-37

DC-8-20ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100	175	1211.68	6.91	4.73	2318.03	13.21	9.05
250	283	1147.84	4.04	2.77	1654.73	5.82	3.99
500	358	1108.27	3.10	2.13	1202.83	3.37	2.31
750	393	1091.62	2.78	1.90	999.57	2.55	1.74
1,000	413	1081.98	2.62	1.79	881.98	2.13	1.46
2,000	447	1064.89	2.38	1.63	679.60	1.52	1.04
3,000	460	1058.55	2.30	1.58	604.48	1.31	.90
AVG. STAGE	402	1086.53	2.70	1.85	939.47	2.33	1.60

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,240,000

FUEL COST = 15¢/Gallon

TABLE A-38

DC-8-20ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1420.60	8.10	5.55			
250		1360.93	4.79	3.28			
500		1328.26	3.72	2.55			
750		1315.96	3.35	2.30			
1,000		1308.82	3.17	2.17			
2,000		1295.51	2.90	1.98			
3,000		1290.57	2.80	1.92			
AVG. STAGE		1311.98	3.26	2.23			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,240,000

FUEL COST = 30¢/Gallon

TABLE A-39

DC-8-20ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1838.44	10.48	7.18			
250		1787.13	6.29	4.31			
500		1768.26	4.95	3.39			
750		1764.63	4.49	3.08			
1,000		1762.50	4.27	2.92			
2,000		1756.74	3.93	2.69			
3,000		1754.60	3.81	2.61			
AVG. STAGE		1762.88	4.38	3.00			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,240,000

FUEL COST = 60¢/Gallon

TABLE A-40

DC-8-20ER - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.825	.509	.405	.368	.350	.323	.314	.359
INSURANCE	.076	.047	.037	.034	.032	.030	.029	.033
DEPRECIATION	1.591	.982	.782	.711	.675	.624	.607	.693
MAINTENANCE:								
AIRFRAME	.850	.387	.234	.182	.156	.117	.104	.168
ENGINE	.574	.328	.246	.218	.204	.183	.176	.211
FUEL @ 15¢/GAL	.815	.514	.422	.391	.376	.353	.346	.383
TOTAL DOC	4.731	2.767	2.126	1.904	1.793	1.630	1.576	1.847
FUEL @ 30¢/GAL	1.630	1.028	.844	.782	.752	.706	.691	.767
TOTAL DOC	5.546	3.281	2.548	2.295	2.169	1.983	1.921	2.231
FUEL @ 60¢/GAL	3.262	2.055	1.687	1.565	1.504	1.412	1.382	1.533
TOTAL DOC	7.178	4.308	3.391	3.078	2.921	2.689	2.612	2.997

TABLE A-41

DC-8-50R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	189	1390.06	7.37	5.05	2545.50	13.49	9.24
250	295	1298.60	4.42	3.02	1749.53	5.95	4.07
500	362	1240.89	3.42	2.35	1243.19	3.43	2.35
750	392	1215.21	3.09	2.12	1017.86	2.59	1.78
1,000	409	1199.67	2.94	2.01	887.84	2.18	1.49
2,000	437	1175.37	2.69	1.84	675.07	1.55	1.06
3,000	447	1166.50	2.61	1.79	597.38	1.34	.91
AVG. STAGE	390	1216.61	3.11	2.13	1030.38	2.64	1.81

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,730,000

FUEL COST = 15¢/Gallon

TABLE A-42

DC-8-50R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1607.70	8.52	5.84			
250		1507.41	5.13	3.51			
500		1444.57	3.99	2.73			
750		1416.61	3.61	2.47			
1,000		1398.95	3.43	2.35			
2,000		1372.45	3.14	2.15			
3,000		1362.76	3.05	2.09			
AVG. STAGE		1418.10	3.63	2.49			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,730,000

FUEL COST = 30¢/Gallon

TABLE A-43

DC-8-50R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		2042.94	10.83	7.42			
250		1925.05	6.55	4.48			
500		1851.94	5.11	3.50			
750		1819.41	4.63	3.17			
1,000		1797.51	4.40	3.02			
2,000		1766.59	4.05	2.77			
3,000		1755.29	3.93	2.69			
AVG. STAGE		1821.09	4.66	3.19			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,730,000

FUEL COST = 60¢/Gallon

TABLE A-44

DC-8-50R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.773	.495	.402	.371	.357	.334	.326	.373
INSURANCE	.093	.060	.049	.045	.043	.040	.039	.045
DEPRECIATION	1.964	1.260	1.023	.944	.908	.849	.829	.949
MAINTENANCE:								
AIRFRAME	.883	.403	.244	.190	.164	.124	.111	.193
ENGINE	.543	.319	.243	.218	.206	.188	.181	.219
FUEL @ 15¢/GAL	.790	.487	.385	.351	.335	.309	.301	.353
TOTAL DOC	5.046	3.024	2.346	2.119	2.013	1.844	1.787	2.132
FUEL @ 30¢/GAL	1.580	.973	.770	.703	.669	.618	.601	.706
TOTAL DOC	5.836	3.510	2.731	2.471	2.347	2.153	2.087	2.485
FUEL @ 60¢/GAL	3.160	1.946	1.540	1.405	1.338	1.236	1.203	1.412
TOTAL DOC	7.416	4.483	3.501	3.173	3.016	2.771	2.689	3.191

TABLE A-45

DC-8-50DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	189	1069.94	5.67	3.88	2545.50	13.49	9.24
250	295	996.71	3.39	2.32	1749.53	5.95	4.07
500	362	944.97	2.61	1.79	1243.19	3.43	2.35
750	392	921.95	2.35	1.61	1017.86	2.59	1.78
1,000	409	907.82	2.22	1.52	887.84	2.18	1.49
2,000	437	886.03	2.03	1.39	675.07	1.55	1.06
3,000	447	878.07	1.96	1.35	597.38	1.34	.91
AVG. STAGE	390	923.21	2.36	1.62	1030.38	2.64	1.81

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $3,658,000

FUEL COST = 15¢/Gallon

TABLE A-46

DC-8-50DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1289.02	6.83	4.68			
250		1223.46	4.16	2.85			
500		1171.50	3.23	2.22			
750		1148.37	2.92	2.00			
1,000		1133.26	2.78	1.90			
2,000		1111.30	2.54	1.74			
3,000		1103.29	2.47	1.69			
AVG. STAGE		1149.60	2.94	2.01			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $3,658,000

FUEL COST = 30¢/Gallon

TABLE A-47

DC-8-50DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1727.15	9.15	6.27			
250		1676.95	5.70	3.91			
500		1624.55	4.48	3.07			
750		1601.19	4.08	2.79			
1,000		1584.12	3.88	2.66			
2,000		1561.85	3.58	2.45			
3,000		1553.72	3.48	2.38			
AVG. STAGE		1602.39	4.10	2.81			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$3,658,000

FUEL COST = 60¢/Gallon

TABLE A-48

DC-8-50DR - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.773	.495	.402	.371	.357	.334	.326	.373
INSURANCE	.044	.029	.023	.021	.020	.019	.019	.021
DEPRECIATION	.930	.597	.484	.447	.430	.402	.392	.449
MAINTENANCE:								
AIRFRAME	.883	.403	.244	.190	.164	.124	.111	.193
ENGINE	.459	.269	.205	.184	.174	.158	.152	.185
FUEL @ 15¢/GAL	.795	.528	.428	.395	.378	.353	.345	.397
TOTAL DOC	3.884	2.321	1.786	1.608	1.523	1.390	1.345	1.618
FUEL @ 30¢/GAL	1.590	1.056	.857	.790	.757	.706	.690	.793
TOTAL DOC	4.679	2.849	2.215	2.003	1.902	1.743	1.690	2.014
FUEL @ 60¢/GAL	3.181	2.112	1.713	1.580	1.513	1.413	1.380	1.587
TOTAL DOC	6.270	3.905	3.071	2.793	2.658	2.450	2.380	2.808

TABLE A-49

DC-8-50ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	189	1382.58	7.33	5.02	2545.50	13.49	9.24
250	295	1298.19	4.41	3.02	1749.53	5.95	4.07
500	362	1242.54	3.43	2.35	1243.19	3.43	2.35
750	392	1217.80	3.10	2.12	1017.86	2.59	1.78
1,000	409	1202.74	2.95	2.02	887.84	2.18	1.49
2,000	437	1179.31	2.70	1.85	675.07	1.55	1.06
3,000	447	1170.76	2.62	1.79	597.38	1.34	.91
AVG. STAGE	390	1219.14	3.12	2.14	1030.38	2.64	1.81

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,620,000

FUEL COST = 15¢/Gallon

TABLE A-50

DC-8-50ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1600.79	8.48	5.81			
250		1514.64	5.15	3.53			
500		1455.93	4.02	2.75			
750		1429.85	3.64	2.49			
1,000		1413.16	3.46	2.37			
2,000		1388.39	3.18	2.18			
3,000		1379.35	3.09	2.11			
AVG. STAGE		1431.23	3.66	2.51			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,620,000

FUEL COST = 30¢/Gallon

TABLE A-51

DC-8-50ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100		2037.25	10.80	7.40			
250		1947.54	6.62	4.54			
500		1882.74	5.20	3.56			
750		1853.96	4.72	3.23			
1,000		1834.00	4.49	3.08			
2,000		1806.55	4.14	2.83			
3,000		1796.53	4.02	2.75			
AVG. STAGE		1855.41	4.75	3.25			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 146

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,620,000

FUEL COST = 60¢/Gallon

TABLE A-52

DC-8-50ER - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.773	.495	.402	.371	.357	.334	.326	.373
INSURANCE	.092	.060	.048	.044	.043	.040	.039	.044
DEPRECIATION	1.936	1.242	1.008	.931	.895	.836	.817	.935
MAINTENANCE:								
AIRFRAME	.883	.403	.244	.190	.164	.124	.111	.193
ENGINE	.543	.319	.243	.218	.206	.188	.181	.219
FUEL @ 15¢/GAL	.792	.504	.404	.370	.353	.328	.320	.372
TOTAL DOC	5.019	3.023	2.349	2.124	2.018	1.850	1.794	2.136
FUEL @ 30¢/GAL	1.584	1.008	.807	.740	.706	.656	.639	.743
TOTAL DOC	5.811	3.527	2.752	2.494	2.371	2.178	2.113	2.507
FUEL @ 60¢/GAL	3.169	2.016	1.614	1.480	1.413	1.312	1.278	1.487
TOTAL DOC	7.396	4.535	3.559	3.234	3.078	2.834	2.752	3.251

TABLE A-53

DC-8-61R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	169	1551.44	9.15	4.51	2871.86	16.94	8.35
250	281	1470.89	5.24	2.58	2095.85	7.46	3.68
500	357	1411.62	3.95	1.95	1538.06	4.31	2.12
750	387	1381.60	3.57	1.76	1263.53	3.27	1.61
1,000	405	1367.86	3.38	1.66	1111.88	2.75	1.35
2,000	435	1349.24	3.10	1.53	854.76	1.97	.97
3,000	448	1346.34	3.01	1.48	762.70	1.70	.84
AVG. STAGE	392	1379.69	3.52	1.73	1229.61	3.14	1.55

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,470,000

FUEL COST = 15¢/GALLON

TABLE A-54

DC-8-61R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1771.79	10.45	5.15			
250		1690.89	6.02	2.97			
500		1629.81	4.56	2.25			
750		1597.69	4.13	2.04			
1,000		1585.74	3.92	1.93			
2,000		1574.82	3.62	1.78			
3,000		1578.58	3.53	1.74			
AVG. STAGE		1597.43	4.07	2.01			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,470,000

FUEL COST = 30¢/Gallon

TABLE A-55

DC-8-61R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2212.50	13.05	6.43			
250		2130.91	7.59	3.74			
500		2066.18	5.79	2.85			
750		2029.87	5.25	2.59			
1,000		2021.50	4.99	2.46			
2,000		2025.98	4.66	2.30			
3,000		2043.06	4.56	2.25			
AVG. STAGE		2032.92	5.18	2.55			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,470,000

FUEL COST = 60¢/Gallon

TABLE A-56

DC-8-61R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.624	.376	.296	.274	.261	.243	.236	.270
INSURANCE	.093	.056	.044	.041	.039	.036	.035	.040
DEPRECIATION	1.945	1.174	.923	.853	.814	.758	.737	.841
MAINTENANCE:								
AIRFRAME	.783	.350	.206	.159	.135	.100	.088	.153
ENGINE	.424	.238	.177	.159	.150	.136	.130	.156
FUEL @ 15¢/GAL	.640	.386	.301	.275	.265	.256	.256	.274
TOTAL DOC	4.509	2.580	1.947	1.761	1.664	1.529	1.482	1.734
FUEL @ 30¢/GAL	1.281	.772	.602	.550	.530	.511	.511	.547
TOTAL DOC	5.150	2.966	2.248	2.036	1.929	1.784	1.737	2.007
FUEL @ 60¢/GAL	2.562	1.543	1.204	1.101	1.060	1.022	1.022	1.094
TOTAL DOC	6.431	3.737	2.850	2.587	2.459	2.295	2.248	2.554

TABLE A-57

DC-8-61DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC			TOTAL IOC		
		$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	169	1237.14	7.30	3.60	2871.86	16.94	8.35
250	281	1159.89	4.13	2.03	2095.85	7.46	3.68
500	357	1101.64	3.08	1.52	1538.06	4.31	2.12
750	387	1072.18	2.77	1.37	1263.53	3.27	1.61
1,000	405	1059.29	2.62	1.29	1111.88	2.75	1.35
2,000	435	1044.10	2.40	1.18	854.76	1.97	.97
3,000	448	1045.21	2.33	1.15	762.70	1.70	.84
AVG. STAGE	392	1070.61	2.73	1.35	1229.61	3.14	1.55

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,750,000

FUEL COST = 15¢/Gallon

TABLE A-58

DC-8-61DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1481.75	8.74	4.31			
250		1406.08	5.01	2.47			
500		1346.06	3.77	1.86			
750		1314.59	3.40	1.68			
1,000		1304.09	3.22	1.59			
2,000		1299.56	2.99	1.47			
3,000		1311.19	2.93	1.44			
AVG. STAGE		1314.95	3.35	1.65			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,750,000

FUEL COST = 30¢/Gallon

TABLE A-59

DC-8-61DR

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		1970.93	11.63	5.73			
250		1898.47	6.76	3.33			
500		1834.93	5.14	2.53			
750		1799.42	4.65	2.29			
1,000		1793.67	4.43	2.18			
2,000		1810.48	4.16	2.05			
3,000		1843.14	4.12	2.03			
AVG. STAGE		1803.62	4.60	2.27			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,750,000

FUEL COST = 60¢/Gallon

TABLE A-60

DC-8-61DR - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.624	.376	.296	.274	.261	.243	.236	.270
INSURANCE	.051	.031	.024	.022	.021	.020	.019	.022
DEPRECIATION	1.068	.644	.507	.468	.448	.417	.404	.461
MAINTENANCE:								
AIRFRAME	.783	.350	.206	.159	.135	.100	.088	.153
ENGINE	.359	.201	.149	.134	.126	.114	.110	.132
FUEL @ 15¢/GAL	.711	.432	.337	.309	.298	.289	.293	.307
TOTAL DOC	3.596	2.034	1.519	1.366	1.289	1.183	1.150	1.345
FUEL @ 30¢/GAL	1.422	.864	.674	.618	.596	.579	.585	.614
TOTAL DOC	4.307	2.466	1.856	1.675	1.587	1.473	1.442	1.652
FUEL @ 60¢/GAL	2.843	1.727	1.349	1.236	1.191	1.158	1.171	1.228
TOTAL DOC	5.728	3.329	2.531	2.293	2.182	2.052	2.028	2.266

TABLE A-61

DC-8-61ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	169	1554.64	9.17	4.52	2871.86	16.94	8.35
250	281	1474.93	5.25	2.59	2095.85	7.46	3.68
500	357	1415.66	3.96	1.95	1538.06	4.31	2.12
750	387	1385.71	3.58	1.77	1263.53	3.27	1.61
1,000	405	1372.22	3.39	1.67	1111.88	2.75	1.35
2,000	435	1354.93	3.12	1.54	854.76	1.97	.97
3,000	448	1353.68	3.02	1.49	762.70	1.70	.84
AVG. STAGE	392	1383.93	3.53	1.74	1229.61	3.14	1.55

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,360,000

FUEL COST = 15¢/Gallon

TABLE A-62

DC-8-61ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1785.54	10.53	5.19			
250		1706.34	6.07	2.99			
500		1645.27	4.61	2.27			
750		1613.27	4.17	2.06			
1,000		1601.82	3.96	1.95			
2,000		1593.55	3.67	1.81			
3,000		1600.63	3.57	1.76			
AVG. STAGE		1613.27	4.11	2.03			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,360,000

FUEL COST = 30¢/Gallon

TABLE A-63

DC-8-61ER

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2247.36	13.26	6.53			
250		2169.13	7.72	3.80			
500		2104.48	5.89	2.90			
750		2068.39	5.35	2.64			
1,000		2061.02	5.09	2.51			
2,000		2070.81	4.76	2.35			
3,000		2094.52	4.68	2.30			
AVG. STAGE		2071.94	5.28	2.60			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 203

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $10,360,000

FUEL COST = 60¢/Gallon

TABLE A-64

DC-8-61ER - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.624	.376	.296	.274	.261	.243	.236	.270
INSURANCE	.091	.055	.044	.040	.038	.036	.035	.039
DEPRECIATION	1.925	1.162	.913	.844	.806	.750	.728	.832
MAINTENANCE:								
AIRFRAME	.783	.350	.206	.159	.135	.100	.088	.153
ENGINE	.424	.238	.177	.159	.150	.136	.130	.156
FUEL @ 15¢/GAL	.671	.406	.317	.290	.280	.270	.272	.288
TOTAL DOC	4.518	2.587	1.953	1.766	1.670	1.535	1.489	1.738
FUEL @ 30¢/GAL	1.342	.811	.633	.580	.559	.541	.544	.576
TOTAL DOC	5.189	2.992	2.269	2.056	1.949	1.806	1.761	2.026
FUEL @ 60¢/GAL	2.684	1.623	1.267	1.160	1.118	1.081	1.087	1.152
TOTAL DOC	6.531	3.804	2.903	2.636	2.508	2.346	2.304	2.602

TABLE A-65

DC-9-10R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	185	598.39	3.23	4.62	1068.02	5.77	8.24
250	291	590.97	2.03	2.90	747.09	2.57	3.67
500	352	580.58	1.65	2.36	531.80	1.51	2.16
750	381	575.30	1.51	2.16	439.83	1.16	1.65
1,000	400	574.31	1.44	2.05	390.20	.98	1.39
1,250	401	574.39	1.41	2.01	355.74	.87	1.24
1,500	417	575.79	1.38	1.97	333.16	.80	1.14
AVG. STAGE	309	587.49	1.90	2.71	685.30	2.22	3.17

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 70

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $2,500,000

FUEL COST = 15¢/GALLON

TABLE A-66

DC-9-10R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		694.37	3.75	5.36			
250		695.93	2.39	3.42			
500		686.07	1.95	2.78			
750		680.20	1.79	2.55			
1,000		680.77	1.70	2.43			
1,250		682.68	1.67	2.39			
1,500		686.64	1.65	2.35			
AVG. STAGE		692.11	2.24	3.20			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 70

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $2,500,000

FUEL COST = 30¢/GALLON

TABLE A-67

DC-9-10R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100		886.33	4.79	6.84			
250		905.86	3.12	4.45			
500		897.05	2.55	3.64			
750		889.99	2.34	3.34			
1,000		893.69	2.23	3.19			
1,250		899.26	2.20	3.14			
1,500		908.33	2.18	3.11			
AVG. STAGE		901.36	2.91	4.16			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 70

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $2,500,000

FUEL COST = 60¢/GALLON

TABLE A-68

DC-9-10R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	1.144	.729	.602	.557	.530	.519	.509	.685
INSURANCE	.076	.048	.040	.037	.035	.034	.033	.045
DEPRECIATION	1.588	1.012	.835	.772	.735	.720	.706	.951
MAINTENANCE:								
AIRFRAME	.582	.317	.233	.204	.188	.180	.174	.289
ENGINE	.486	.282	.218	.195	.183	.177	.172	.260
FUEL @ 15¢/GAL	.740	.516	.428	.394	.380	.379	.380	.483
TOTAL DOC	4.616	2.904	2.356	2.159	2.051	2.009	1.974	2.713
FUEL @ 30¢/GAL	1.481	1.032	.856	.787	.760	.757	.760	.967
TOTAL DOC	5.357	3.420	2.784	2.552	2.431	2.387	2.354	3.197
FUEL @ 60¢/GAL	2.962	2.063	1.712	1.574	1.521	1.515	1.520	1.933
TOTAL DOC	6.838	4.451	3.640	3.339	3.192	3.145	3.114	4.163

TABLE A-69

DC-9-30R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100	182	654.31	3.60	3.91	1305.30	7.18	7.80
250	284	639.25	2.25	2.45	914.45	3.22	3.50
500	355	628.14	1.77	1.93	670.87	1.89	2.06
750	381	620.27	1.63	1.77	554.27	1.46	1.58
1,000	397	616.58	1.55	1.69	490.62	1.24	1.34
1,250	408	615.14	1.51	1.64	450.75	1.10	1.20
1,500	417	615.37	1.48	1.61	422.92	1.02	1.10
AVG. STAGE	302	638.09	2.11	2.30	861.02	2.85	3.10

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $3,970,000

FUEL COST = 15¢/GALLON

TABLE A-70

DC-9-30R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		752.81	4.14	4.50			
250		747.00	2.63	2.86			
500		739.98	2.09	2.27			
750		731.42	1.92	2.09			
1,000		728.01	1.83	1.99			
1,250		727.62	1.78	1.94			
1,500		729.82	1.75	1.90			
AVG. STAGE		748.05	2.48	2.69			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $3,970,000

FUEL COST = 30¢/GALLON

TABLE A-71

DC-9-30R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		949.83	5.22	5.68			
250		962.48	3.39	3.68			
500		963.67	2.72	2.95			
750		953.73	2.51	2.72			
1,000		950.86	2.40	2.61			
1,250		952.57	2.33	2.53			
1,500		958.73	2.30	2.50			
AVG. STAGE		967.97	3.20	3.48			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $3,970,000

FUEL COST = 60¢/GALLON

TABLE A-72

DC-9-30R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	.894	.572	.458	.427	.410	.398	.390	.538
INSURANCE	.079	.051	.040	.038	.036	.035	.035	.048
DEPRECIATION	1.385	.886	.710	.661	.635	.616	.604	.833
MAINTENANCE:								
AIRFRAME	.590	.306	.209	.179	.163	.153	.147	.278
ENGINE	.375	.219	.165	.148	.140	.135	.131	.203
FUEL @ 15¢/GAL	.589	.412	.343	.318	.305	.300	.298	.396
TOTAL DOC	3.912	2.446	1.925	1.771	1.689	1.637	1.605	2.296
FUEL @ 30¢/GAL	1.178	.824	.686	.635	.610	.599	.597	.791
TOTAL DOC	4.501	2.858	2.268	2.088	1.994	1.936	1.904	2.691
FUEL @ 60¢/GAL	2.355	1.649	1.372	1.270	1.221	1.197	1.194	1.583
TOTAL DOC	5.678	3.683	2.954	2.723	2.605	2.534	2.501	3.483

TABLE A-73

DC-10-10R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	1559.31	9.51	3.43	3955.25	24.13	8.71
250	275	1436.26	5.23	1.89	2903.02	10.57	3.82
500	355	1347.52	3.80	1.37	2144.31	6.05	2.18
750	389	1301.41	3.35	1.21	1769.20	4.55	1.64
1,000	408	1274.90	3.12	1.13	1553.22	3.81	1.37
2,000	445	1237.08	2.78	1.00	1192.33	2.68	.97
3,000	459	1229.52	2.68	.97	1057.38	2.30	.83
AVG. STAGE	399	1285.92	3.22	1.16	1652.37	4.14	1.49

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $14,100,000

FUEL COST = 15¢/Gallon

TABLE A-74

DC-10-10R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1839.05	11.22	4.05			
250		1718.59	6.26	2.26			
500		1631.74	4.60	1.66			
750		1583.94	4.08	1.47			
1,000		1556.49	3.81	1.38			
2,000		1523.96	3.42	1.24			
3,000		1525.02	3.32	1.20			
AVG. STAGE		1566.78	3.93	1.42			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $14,100,000

FUEL COST = 30¢/Gallon

TABLE A-75

DC-10-10R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2398.54	14.63	5.28			
250		2283.26	8.31	3.00			
500		2200.17	6.20	2.24			
750		2149.00	5.53	2.00			
1,000		2119.66	5.19	1.88			
2,000		2097.73	4.71	1.70			
3,000		2116.03	4.61	1.66			
AVG. STAGE		2128.49	5.33	1.93			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $14,100,000

FUEL COST = 60¢/Gallon

TABLE A-76

DC-10-10R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.489	.292	.226	.206	.196	.180	.175	.201
INSURANCE	.093	.056	.044	.040	.038	.035	.034	.039
DEPRECIATION	.992	.592	.459	.419	.399	.365	.354	.408
MAINTENANCE:								
AIRFRAME	.972	.423	.241	.180	.150	.104	.089	.164
ENGINE	.270	.153	.113	.102	.096	.086	.082	.098
FUEL @ 15¢/GAL	.616	.371	.289	.262	.249	.232	.232	.254
TOTAL DOC	3.434	1.887	1.372	1.209	1.128	1.002	.966	1.164
FUEL @ 30¢/GAL	1.232	.742	.578	.525	.498	.465	.464	.508
TOTAL DOC	4.050	2.258	1.661	1.472	1.377	1.235	1.198	1.418
FUEL @ 60¢/GAL	2.464	1.484	1.157	1.050	.996	.930	.929	1.016
TOTAL DOC	5.282	3.000	2.240	1.997	1.875	1.700	1.663	1.926

TABLE A-77

DC-10-40R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	1746.61	10.65	4.23	4083.61	24.91	9.89
250	275	1590.24	5.79	2.30	2975.18	10.83	4.30
500	355	1477.49	4.17	1.65	2175.96	6.14	2.44
750	389	1422.59	3.66	1.45	1781.35	4.58	1.82
1,000	408	1391.08	3.41	1.35	1554.01	3.81	1.51
2,000	445	1343.09	3.02	1.20	1174.03	2.64	1.05
3,000	459	1334.98	2.91	1.15	1031.96	2.25	.89
AVG. STAGE	399	1437.11	3.78	1.50	1885.20	4.95	1.97

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$16,780,000

FUEL COST = 15¢/Gallon

TABLE A-78

DC-10-40R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
(Nautical Mile)	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2091.87	12.76	5.06			
250		1919.30	6.99	2.77			
500		1794.88	5.06	2.01			
750		1734.63	4.46	1.77			
1,000		1700.13	4.17	1.65			
2,000		1652.26	3.71	1.47			
3,000		1654.09	3.60	1.43			
AVG. STAGE		1750.70	4.60	1.83			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $16,780,000

FUEL COST = 30¢/Gallon

TABLE A-79

DC-10-40R

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2782.38	16.97	6.74			
250		2577.41	9.38	3.72			
500		2429.65	6.85	2.72			
750		2358.70	6.07	2.41			
1,000		2318.24	5.68	2.25			
2,000		2270.60	5.10	2.02			
3,000		2292.30	4.99	1.98			
AVG. STAGE		2377.87	6.25	2.48			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $16,780,000

FUEL COST = 60¢/Gallon

TABLE A-80

DC-10-40R - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.559	.334	.258	.236	.224	.206	.200	.241
INSURANCE	.124	.074	.057	.052	.050	.046	.044	.053
DEPRECIATION	1.180	.704	.546	.498	.474	.434	.421	.508
MAINTENANCE:								
AIRFRAME	1.186	.515	.291	.218	.181	.125	.107	.235
ENGINE	.343	.195	.146	.130	.123	.110	.106	.134
FUEL @ 15¢/GAL	.836	.475	.355	.319	.300	.276	.275	.327
TOTAL DOC	4.228	2.297	1.653	1.453	1.352	1.197	1.153	1.498
FUEL @ 30¢/GAL	1.672	.950	.710	.637	.601	.551	.551	.654
TOTAL DOC	5.064	2.772	2.008	1.771	1.653	1.472	1.429	1.825
FUEL @ 60¢/GAL	3.343	1.901	1.421	1.275	1.202	1.102	1.102	1.308
TOTAL DOC	6.735	3.723	2.719	2.409	2.254	2.023	1.980	2.479

TABLE A-81

DC-10-10M

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	1684.03	10.27	3.71	3956.98	24.14	8.71
250	275	1547.63	5.63	2.03	2904.61	10.57	3.82
500	355	1449.28	4.09	1.48	2145.81	6.05	2.18
750	389	1398.97	3.60	1.30	1770.28	4.56	1.64
1,000	408	1372.28	3.36	1.21	1554.27	3.81	1.37
2,000	445	1330.13	2.99	1.08	1192.93	2.68	.97
3,000	459	1320.74	2.87	1.04	1057.70	2.30	.83
AVG. STAGE	399	1384.22	3.47	1.25	1653.49	4.14	1.50

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$23,980,000

FUEL COST = 15¢/GALLON

TABLE A-82

DC-10-10M

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1964.13	11.98	4.33			
250		1827.36	6.65	2.40			
500		1728.73	4.88	1.76			
750		1676.22	4.31	1.56			
1,000		1650.50	4.04	1.46			
2,000		1612.89	3.62	1.31			
3,000		1611.61	3.51	1.27			
AVG. STAGE		1661.65	4.16	1.50			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $23,980,000

FUEL COST = 30¢/GALLON

TABLE A-83

DC-10-10M

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2524.35	15.40	5.56			
250		2386.81	8.69	3.14			
500		2287.64	6.45	2.33			
750		2230.70	5.74	2.07			
1,000		2206.95	5.41	1.95			
2,000		2178.39	4.89	1.77			
3,000		2193.35	4.77	1.72			
AVG. STAGE		2216.53	5.55	2.01			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 277

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $23,980,000

FUEL COST = 60¢/GALLON

TABLE A-84

DC-10-10 M - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.489	.292	.226	.206	.196	.180	.175	.201
INSURANCE	.161	.096	.074	.068	.065	.059	.057	.066
DEPRECIATION	1.055	.629	.488	.445	.424	.388	.376	.433
MAINTENANCE:								
AIRFRAME	1.045	.456	.260	.195	.162	.114	.097	.177
ENGINE	.342	.193	.143	.128	.121	.108	.104	.124
FUEL @ 15¢/GAL	.617	.368	.285	.258	.246	.229	.229	.251
TOTAL DOC	3.709	2.034	1.476	1.300	1.214	1.078	1.038	1.252
FUEL @ 30¢/GAL	1.234	.735	.569	.515	.492	.458	.457	.502
TOTAL DOC	4.326	2.401	1.760	1.557	1.460	1.307	1.266	1.503
FUEL @ 60¢/GAL	2.467	1.470	1.138	1.030	.984	.917	.914	1.004
TOTAL DOC	5.559	3.136	2.329	2.072	1.952	1.766	1.723	2.005

TABLE A-85

DC-10-10 D

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC			TOTAL IOC		
		$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	172	1258.70	7.30	3.67	3025.60	17.55	8.82
250	281	1146.74	4.08	2.05	2165.51	7.71	3.87
500	350	1064.41	3.04	1.53	1553.97	4.44	2.23
750	371	1022.91	2.75	1.38	1254.08	3.38	1.70
1,000	402	1015.59	2.53	1.27	1127.11	2.81	1.41
2,000	434	993.86	2.29	1.15	862.75	1.99	1.00
3,000	446	991.77	2.22	1.12	765.26	1.72	.86
AVG. STAGE	382	1013.85	2.66	1.34	1173.39	3.08	1.55

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 199

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $15,610,000

FUEL COST = 15¢/GALLON

TABLE A-86

DC-10-10 D

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		1510.88	8.76	4.40			
250		1379.90	4.91	2.47			
500		1280.92	3.66	1.84			
750		1228.09	3.31	1.66			
1,000		1229.36	3.06	1.54			
2,000		1214.49	2.80	1.41			
3,000		1220.88	2.74	1.38			
AVG. STAGE		1220.16	3.20	1.61			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 199

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $15,610,000

FUEL COST = 30¢/GALLON

TABLE A-87

DC-10-10 D

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2015.23	11.69	5.87			
250		1846.23	6.57	3.30			
500		1713.93	4.90	2.46			
750		1639.90	4.42	2.22			
1,000		1656.89	4.13	2.07			
2,000		1655.74	3.82	1.92			
3,000		1679.10	3.77	1.89			
AVG. STAGE		1632.77	4.28	2.15			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 199

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $15,610,000

FUEL COST = 60¢/GALLON

TABLE A-88

DC-10-10 D - DOC COMPONENTS VS DISTANCE (¢/ASNM)

BLOCK DISTANCE (N.MI.) / DOC COMPONENT	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.617	.379	.304	.287	.265	.245	.239	.279
INSURANCE	.139	.085	.069	.064	.059	.055	.054	.062
DEPRECIATION	.909	.558	.448	.422	.390	.361	.351	.411
MAINTENANCE:								
AIRFRAME	.926	.414	.245	.191	.160	.117	.103	.175
ENGINE	.343	.199	.153	.141	.129	.118	.113	.136
FUEL @ 15¢/GAL	.735	.417	.311	.279	.268	.255	.258	.272
TOTAL DOC	3.669	2.052	1.530	1.384	1.271	1.151	1.118	1.335
FUEL @ 30¢/GAL	1.470	.834	.622	.557	.535	.511	.516	.544
TOTAL DOC	4.404	2.469	1.841	1.662	1.538	1.407	1.376	1.607
FUEL @ 60¢/GAL	2.940	1.668	1.244	1.115	1.070	1.022	1.033	1.087
TOTAL DOC	5.874	3.303	2.463	2.220	2.073	1.918	1.893	2.150

TABLE A-89

DC-10-40M

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	1931.77	11.78	4.68	4088.72	24.94	9.90
250	275	1758.12	6.40	2.54	2978.78	10.84	4.30
500	355	1632.91	4.60	1.83	2178.47	6.14	2.44
750	389	1570.04	4.04	1.60	1782.91	4.59	1.82
1,000	408	1536.17	3.76	1.49	1555.39	3.81	1.51
2,000	445	1480.84	3.32	1.32	1174.32	2.64	1.05
3,000	459	1470.01	3.20	1.27	1031.87	2.25	.89
AVG. STAGE	381	1587.40	4.17	1.65	1887.14	4.96	1.97

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $28,090,000

FUEL COST = 15¢/GALLON

TABLE A-90

DC-10-40M

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2274.34	13.87	5.51			
250		2083.66	7.58	3.01			
500		1946.15	5.49	2.18			
750		1875.78	4.83	1.92			
1,000		1839.90	4.51	1.79			
2,000		1782.99	4.00	1.59			
3,000		1781.49	3.88	1.54			
AVG. STAGE		1896.00	4.98	1.98			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 525

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $28,090,000

FUEL COST = 30¢/GALLON

TABLE A-91

DC-10-40M

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100		2959.49	18.05	7.16			
250		2734.74	9.95	3.95			
500		2572.64	7.25	2.88			
750		2487.26	6.40	2.54			
1,000		2447.38	6.00	2.38			
2,000		2387.29	5.36	2.13			
3,000		2404.44	5.23	2.08			
AVG. STAGE		2513.20	6.60	2.62			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 252

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $28,090,000

FUEL COST = 60¢/GALLON

TABLE A-92

DC-10-40 M - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.559	.334	.258	.236	.224	.206	.199	.241
INSURANCE	.207	.123	.096	.087	.083	.076	.074	.089
DEPRECIATION	1.359	.811	.628	.573	.546	.500	.485	.585
MAINTENANCE:								
AIRFRAME	1.320	.573	.325	.243	.202	.139	.119	.262
ENGINE	.402	.228	.170	.152	.143	.129	.124	.156
FUEL @ 15¢/GAL	.829	.470	.350	.312	.295	.269	.269	.322
TOTAL DOC	4.676	2.539	1.827	1.603	1.493	1.319	1.270	1.655
FUEL @ 30¢/GAL	1.658	.941	.701	.624	.591	.538	.538	.643
TOTAL DOC	5.505	3.010	2.178	1.915	1.789	1.588	1.539	1.976
FUEL @ 60¢/GAL	3.317	1.881	1.402	1.249	1.181	1.077	1.076	1.287
TOTAL DOC	7.164	3.950	2.879	2.540	2.379	2.127	2.077	2.620

TABLE A-93

DC-10-40 D

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	164	2016.67	12.30	3.76	4670.94	28.49	8.71
250	278	1865.88	6.72	2.05	3463.91	12.47	3.81
500	352	1740.57	4.94	1.51	2523.58	7.17	2.19
750	385	1679.67	4.37	1.34	2079.27	5.41	1.65
1,000	405	1645.76	4.07	1.24	1830.12	4.52	1.38
2,000	443	1594.07	3.59	1.10	1411.04	3.18	.97
3,000	458	1586.63	3.46	1.06	1253.64	2.74	.84
AVG. STAGE	376	1691.39	4.49	1.37	2192.84	5.83	1.78

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 327

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $31,090,000

FUEL COST = 15¢/GALLON

TABLE A-94

DC-10-40 D

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2322.07	14.16	4.33			
250		2187.05	7.87	2.41			
500		2064.74	5.86	1.79			
750		2003.30	5.21	1.59			
1,000		1969.51	4.86	1.49			
2,000		1923.89	4.34	1.33			
3,000		1930.80	4.22	1.29			
AVG. STAGE		2011.28	5.34	1.63			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 327

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $31,090,000

FUEL COST = 30¢/GALLON

TABLE A-95

DC-10-40 D

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	\$/Hr	\$/N.Mi.	¢ / Available Seat N.Mi.**	\$/Hr	\$/N.Mi.	¢ / Available Seat-N.Mi.**
100		2932.86	17.89	5.47			
250		2829.38	10.19	3.11			
500		2713.08	7.71	2.36			
750		2650.55	6.89	2.11			
1,000		2617.03	6.46	1.98			
2,000		2583.53	5.83	1.78			
3,000		2619.12	5.72	1.75			
AVG. STAGE		2651.08	7.04	2.15			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 327

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973\$) = \$31,090,000

FUEL COST = 60¢/GALLON

TABLE A-96

DC-10-40 D - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	2,000	3,000	AVE. STAGE LENGTH
CREW	.427	.252	.199	.182	.173	.158	.153	.186
INSURANCE	.176	.104	.082	.075	.072	.065	.063	.077
DEPRECIATION	1.159	.684	.539	.494	.469	.429	.415	.505
MAINTENANCE:								
AIRFRAME	1.103	.477	.271	.202	.168	.115	.098	.218
ENGINE	.327	.184	.139	.125	.117	.105	.101	.128
FUEL @ 15¢/GAL	.570	.353	.282	.257	.244	.227	.230	.260
TOTAL DOC	3.762	2.054	1.512	1.335	1.243	1.099	1.060	1.374
FUEL @ 30¢/GAL	1.140	.707	.563	.515	.489	.455	.459	.520
TOTAL DOC	4.332	2.408	1.793	1.593	1.488	1.327	1.289	1.634
FUEL @ 60¢/GAL	2.279	1.414	1.126	1.029	.978	.910	.919	1.040
TOTAL DOC	5.471	3.115	2.356	2.107	1.977	1.782	1.749	2.154

TABLE A-97

DC-9-30 D1

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	182	636.21	3.50	2.99	1591.49	8.75	7.48
250	281	608.55	2.17	1.85	1108.95	3.95	3.37
500	342	590.33	1.72	1.47	803.90	2.35	2.01
750	369	582.84	1.58	1.35	670.18	1.81	1.55
1,000	385	578.29	1.50	1.29	595.08	1.55	1.32
1,250	394	576.19	1.46	1.25	547.02	1.39	1.19
1,500	401	697.02	1.74	1.23	513.64	1.28	1.09
AVG. STAGE	296	718.40	2.43	1.75	1037.34	3.51	3.00

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 117

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,400,000

FUEL COST = 15¢/GALLON

TABLE A-98

DC-9-30 D1

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		743.68	4.09	3.50			
250		722.12	2.57	2.20			
500		707.03	2.06	1.76			
750		701.40	1.90	1.62			
1,000		697.55	1.81	1.55			
1,250		696.71	1.77	1.51			
1,500		575.18	1.43	1.49			
AVG. STAGE		604.18	2.04	2.08			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 117

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,400,000

FUEL COST = 30¢/GALLON

TABLE A-99

DC-9-30 D1

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100		958.60	5.27	4.51			
250		949.27	3.38	2.89			
500		940.41	2.75	2.35			
750		938.51	2.54	2.17			
1,000		936.07	2.43	2.08			
1,250		937.75	2.38	2.03			
1,500		940.72	2.35	2.00			
AVG. STAGE		946.85	3.20	2.73			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 117

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $7,400,000

FUEL COST = 60¢/GALLON

TABLE A-100

DC-9-30 D1 - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	.708	.458	.376	.348	.334	.326	.321	.435
INSURANCE	.116	.075	.062	.057	.055	.054	.052	.071
DEPRECIATION	.761	.493	.404	.375	.360	.351	.345	.467
MAINTENANCE:								
AIRFRAME	.592	.298	.200	.168	.151	.142	.135	.271
ENGINE	.309	.182	.140	.126	.120	.115	.113	.171
FUEL @ 15¢/GAL	.505	.346	.291	.274	.265	.261	.260	.330
TOTAL DOC	2.991	1.852	1.473	1.348	1.285	1.249	1.226	1.745
FUEL @ 30¢/GAL	1.010	.691	.583	.549	.530	.522	.519	.660
TOTAL DOC	3.496	2.197	1.765	1.623	1.550	1.510	1.485	2.075
FUEL @ 60¢/GAL	2.020	1.382	1.165	1.097	1.060	1.045	1.039	1.320
TOTAL DOC	4.506	2.888	2.347	2.171	2.080	2.033	2.005	2.735

TABLE A-101

DC-9-30 D2

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100	182	684.99	3.77	3.09	1652.01	9.09	7.45
250	281	658.40	2.34	1.92	1150.06	4.09	3.36
500	342	637.44	1.86	1.53	832.55	2.43	1.99
750	369	628.10	1.70	1.39	693.34	1.88	1.54
1,000	385	622.86	1.62	1.33	615.16	1.60	1.31
1,250	394	620.20	1.57	1.29	565.14	1.43	1.17
1,500	401	618.66	1.54	1.26	530.38	1.32	1.08
AVG. STAGE	296	652.10	2.20	1.81	1075.45	3.63	2.98

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 122

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $8,950,000

FUEL COST = 15¢/GALLON

TABLE A-102

DC-9-30 D2

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED* Nautical Mile / Hr	TOTAL DOC $/Hr	TOTAL DOC $/N.Mi.	TOTAL DOC ¢ / Available Seat N.Mi.**	TOTAL IOC $/Hr	TOTAL IOC $/N.Mi.	TOTAL IOC ¢ / Available Seat-N.Mi.**
100		789.52	4.34	3.56			
250		771.35	2.75	2.25			
500		751.52	2.19	1.80			
750		742.55	2.01	1.65			
1,000		737.50	1.92	1.57			
1,250		735.67	1.87	1.53			
1,500		735.01	1.83	1.50			
AVG. STAGE		763.95	2.58	2.12			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 122

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $8,950,000

FUEL COST = 30¢/GALLON

TABLE A-103

DC-9-30 D2

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		998.59	5.49	4.50			
250		997.24	3.55	2.91			
500		979.70	2.86	2.34			
750		971.43	2.63	2.16			
1,000		966.79	2.51	2.06			
1,250		966.62	2.45	2.01			
1,500		967.72	2.41	1.98			
AVG. STAGE		987.65	3.34	2.74			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 122

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $8,950,000

FUEL COST = 60¢/GALLON

TABLE A-104

DC-9-30 D2 - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	.680	.441	.361	.335	.322	.314	.308	.418
INSURANCE	.135	.087	.072	.066	.064	.062	.061	.083
DEPRECIATION	.883	.571	.469	.434	.417	.407	.400	.542
MAINTENANCE:								
AIRFRAME	.585	.295	.198	.166	.150	.140	.134	.268
ENGINE	.334	.198	.153	.138	.130	.126	.123	.185
FUEL @ 15¢/GAL	.471	.329	.273	.254	.244	.240	.238	.310
TOTAL DOC	3.088	1.921	1.526	1.393	1.327	1.289	1.264	1.806
FUEL @ 30¢/GAL	.942	.659	.546	.508	.489	.480	.476	.620
TOTAL DOC	3.559	2.251	1.799	1.647	1.572	1.529	1.502	2.116
FUEL @ 60¢/GAL	1.885	1.318	1.092	1.016	.977	.960	.951	1.239
TOTAL DOC	4.502	2.910	2.345	2.155	2.060	2.009	1.977	2.735

TABLE A-105

DC-9-30 D3

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi.**	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi.**
100	182	549.75	3.02	3.29	1319.34	7.26	7.89
250	284	532.74	1.88	2.04	924.22	3.25	3.54
500	355	520.36	1.47	1.60	677.96	1.91	2.08
750	381	511.86	1.34	1.46	560.06	1.47	1.60
1,000	397	507.78	1.28	1.39	495.67	1.25	1.36
1,250	408	506.03	1.24	1.35	455.34	1.11	1.21
1,500	417	506.00	1.21	1.32	427.17	1.03	1.11
AVG. STAGE	302	531.04	1.76	1.91	870.18	2.88	3.13

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,410,000

FUEL COST = 15¢/GALLON

TABLE A-106

DC-9-30 D3

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		647.44	3.56	3.87			
250		639.49	2.25	2.45			
500		631.06	1.78	1.93			
750		621.76	1.63	1.78			
1,000		617.85	1.56	1.69			
1,250		617.02	1.51	1.64			
1,500		618.84	1.49	1.61			
AVG. STAGE		639.72	2.12	2.30			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,410,000

FUEL COST = 30¢/GALLON

TABLE A-107

DC-9-30 D3

TOTAL DOC, IOC AND BLOCK SPEED VS DISTANCE

DISTANCE (Nautical Mile)	BLOCK SPEED*	TOTAL DOC			TOTAL IOC		
	Nautical Mile / Hr	$/Hr	$/N.Mi.	¢ / Available Seat N.Mi. **	$/Hr	$/N.Mi.	¢ / Available Seat-N.Mi. **
100		842.83	4.64	5.04			
250		852.99	3.00	3.26			
500		852.47	2.40	2.61			
750		841.58	2.21	2.40			
1,000		837.98	2.11	2.30			
1,250		839.00	2.05	2.23			
1,500		844.51	2.03	2.20			
AVG. STAGE		857.07	2.84	3.08			

* FROM DAC PERFORMANCE DATA FOR BASELINE FLIGHT PROFILES

** TOTAL NUMBER OF SEATS = 92

LOAD FACTOR = 58.0%

AIRCRAFT PRICE (1973$) = $5,410,000

FUEL COST = 60¢/GALLON

TABLE A-108

DC-9-30 D3 - DOC COMPONENTS VS DISTANCE (¢/ASNM)

DOC COMPONENT \ BLOCK DISTANCE (N.MI.)	100	250	500	750	1,000	1,250	1,500	AVE. STAGE LENGTH
CREW	.894	.572	.459	.427	.410	.398	.390	.538
INSURANCE	.108	.069	.055	.051	.049	.048	.047	.065
DEPRECIATION	.708	.453	.363	.338	.324	.315	.309	.426
MAINTENANCE:								
AIRFRAME	.623	.320	.217	.185	.168	.157	.151	.291
ENGINE	.370	.216	.162	.146	.138	.133	.129	.200
FUEL @ 15¢/GAL	.584	.408	.339	.314	.302	.295	.294	.391
TOTAL DOC	3.287	2.038	1.595	1.461	1.391	1.346	1.320	1.911
FUEL @ 30¢/GAL	1.168	.817	.678	.628	.603	.591	.588	.782
TOTAL DOC	3.871	2.447	1.934	1.775	1.692	1.642	1.614	2.302
FUEL @ 60¢/GAL	2.336	1.634	1.357	1.256	1.206	1.181	1.177	1.564
TOTAL DOC	5.039	3.264	2.613	2.403	2.295	2.232	2.203	3.084

TABLE A-109

N80-2.15 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 15¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN. FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1256.12	6.28	3.12	1255.37	6.28	3.12	1264.53	6.32	3.15	1286.90	6.43	3.20
250	1126.97	3.88	1.93	1118.30	3.89	1.94	1111.32	3.96	1.97	1117.90	4.02	2.00
500	1076.02	2.93	1.46	1053.93	2.93	1.46	1044.01	2.99	1.49	1031.21	3.16	1.57
750	1044.24	2.65	1.32	1022.82	2.66	1.32	1010.45	2.71	1.35	994.05	2.86	1.42
1,000	1032.14	2.48	1.23	1005.74	2.49	1.24	994.50	2.54	1.26	975.13	2.70	1.34
1,250	1022.49	2.39	1.19	996.15	2.41	1.20	984.17	2.44	1.21	960.70	2.62	1.30
1,500	1017.00	2.33	1.16	987.63	2.35	1.17	975.65	2.39	1.19	953.13	2.56	1.27
Aircraft Price (1973 $)	$ 15,700,000			$ 15,710,000			$ 15,854,000			$ 16,086,000		

TABLE A-110

N80-2.15 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 30¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN. FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1448.66	7.24	3.60	1447.91	7.24	3.60	1457.06	7.29	3.62	1479.44	7.40	3.68
250	1311.80	4.51	2.25	1298.43	4.52	2.25	1282.37	4.57	2.27	1284.57	4.62	2.30
500	1271.92	3.46	1.72	1232.71	3.43	1.70	1211.53	3.47	1.72	1184.85	3.63	1.80
750	1238.66	3.14	1.56	1200.78	3.12	1.55	1174.74	3.15	1.57	1141.23	3.29	1.64
1,000	1230.36	2.95	1.47	1182.68	2.93	1.46	1158.68	2.95	1.47	1119.80	3.10	1.54
1,250	1221.84	2.85	1.42	1174.07	2.84	1.41	1148.47	2.85	1.42	1101.86	3.01	1.50
1,500	1218.23	2.79	1.39	1164.50	2.77	1.38	1139.07	2.79	1.39	1093.98	2.94	1.46
Aircraft Price (1973 $)	$ 15,700,000			$ 15,710,000			$ 15,854,000			$ 16,086,000		

TABLE A-111

N80-2.15 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 60¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN. FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1833.73	9.17	4.56	1832.98	9.16	4.56	1842.14	9.21	4.58	1864.51	9.32	4.64
250	1681.47	5.78	2.88	1658.70	5.77	2.87	1624.48	5.78	2.88	1617.90	5.82	2.90
500	1663.71	4.53	2.25	1590.27	4.42	2.20	1546.56	4.42	2.20	1492.14	4.57	2.27
750	1627.50	4.12	2.05	1556.69	4.05	2.01	1503.32	4.03	2.00	1435.60	4.13	2.06
1,000	1626.82	3.90	1.94	1536.55	3.81	1.90	1487.04	3.79	1.89	1409.15	3.90	1.94
1,250	1620.53	3.79	1.88	1529.91	3.70	1.84	1477.06	3.66	1.82	1384.17	3.78	1.88
1,500	1620.71	3.71	1.84	1518.25	3.61	1.80	1465.91	3.60	1.79	1375.68	3.70	1.84
Aircraft Price (1973 $)	$ 15,700,000			$ 15,710,000			$ 15,854,000			$ 16,086,000		

TABLE A-112

N80-2.15 INDIRECT OPERATING COSTS VS DISTANCE

DISTANCE (NM)	DOC 15¢			DOC 30¢			DOC 60¢			MINIMUM FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	3209.10	16.05	7.98	3198.59	15.99	7.96	3201.07	16.01	7.96	3220.04	16.10	8.01
250	2084.87	7.17	3.57	2058.23	7.16	3.56	2020.19	7.19	3.58	2011.50	7.24	3.60
500	1525.94	4.15	2.07	1495.18	4.16	2.07	1462.70	4.18	2.08	1393.68	4.26	2.12
750	1247.42	3.16	1.57	1220.03	3.17	1.58	1193.17	3.20	1.59	1136.20	3.27	1.63
1,000	1105.14	2.65	1.32	1076.57	2.67	1.33	1055.69	2.69	1.34	999.88	2.77	1.38
1,250	1007.18	2.35	1.17	981.54	2.37	1.18	964.22	2.39	1.19	907.51	2.48	1.23
1,500	940.66	2.15	1.07	913.61	2.17	1.08	895.59	2.20	1.09	847.01	2.28	1.13

TABLE A-113

N80-2.30 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 15 ¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1324.74	7.95	3.96	1331.94	7.99	3.98	1336.29	8.02	3.99	1357.40	8.14	4.05
250	1233.72	4.44	2.21	1238.92	4.46	2.22	1237.73	4.51	2.24	1253.15	4.56	2.27
500	1173.50	3.29	1.64	1165.43	3.29	1.64	1160.67	3.30	1.64	1151.83	3.48	1.73
750	1147.72	2.89	1.44	1134.18	2.92	1.45	1117.04	2.98	1.48	1104.50	3.17	1.58
1000	1126.26	2.71	1.35	1112.23	2.75	1.37	1096.66	2.81	1.40	1081.29	3.01	1.50
1500	1107.93	2.55	1.27	1093.47	2.58	1.28	1073.90	2.64	1.31	1057.58	2.83	1.41
2000	1102.83	2.45	1.22	1083.92	2.49	1.24	1064.56	2.55	1.27	1045.12	2.75	1.37
2500	1096.32	2.41	1.20	1078.52	2.45	1.22	1058.43	2.51	1.25	1039.54	2.70	1.35
3000	1097.86	2.39	1.19	1077.75	2.42	1.21	1057.56	2.49	1.24	1035.65	2.68	1.34
Aircraft Price (1973$)	$ 18,134,000			$ 18,286,000			$ 18,412,000			$ 18,682,000		

TABLE A-114

N80-2.30 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 30¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1522.50	9.14	4.55	1529.70	9.18	4.57	1534.05	9.20	4.58	1555.16	9.33	4.64
250	1432.73	5.16	2.57	1437.92	5.18	2.57	1434.54	5.22	2.60	1449.97	5.28	2.63
500	1378.19	3.86	1.92	1359.14	3.83	1.91	1348.28	3.83	1.91	1326.79	4.01	1.99
750	1357.39	3.42	1.70	1329.06	3.42	1.70	1296.14	3.46	1.72	1267.98	3.63	1.81
1000	1333.41	3.21	1.60	1304.39	3.22	1.60	1274.19	3.26	1.62	1240.74	3.45	1.72
1500	1317.53	3.03	1.51	1287.62	3.04	1.51	1249.25	3.07	1.53	1213.52	3.25	1.62
2000	1318.16	2.93	1.46	1279.57	2.94	1.46	1241.33	2.98	1.48	1199.33	3.16	1.57
2500	1312.27	2.89	1.44	1275.80	2.90	1.44	1235.95	2.94	1.46	1194.71	3.11	1.55
3000	1320.06	2.87	1.43	1278.94	2.87	1.43	1238.77	2.91	1.45	1191.51	3.09	1.54
Aircraft Price (1973 $)	$ 18,134,000			$ 18,286,000			$ 18,412,000			$ 18,682,000		

TABLE A-115

N80-2.30 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 60¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1918.03	11.51	5.73	1925.22	11.55	5.75	1929.57	11.58	5.76	1950.69	11.70	5.82
250	1830.73	6.59	3.28	1835.93	6.61	3.29	1828.18	6.65	3.31	1843.60	6.71	3.34
500	1787.57	5.01	2.49	1746.57	4.93	2.45	1723.52	4.89	2.44	1676.69	5.06	2.52
750	1776.72	4.48	2.23	1718.82	4.42	2.20	1654.35	4.41	2.20	1594.95	4.57	2.28
1000	1747.73	4.21	2.10	1688.70	4.17	2.08	1629.25	4.17	2.07	1559.65	4.34	2.16
1500	1736.74	3.99	1.99	1675.93	3.96	1.97	1599.93	3.94	1.96	1525.39	4.09	2.03
2000	1748.82	3.89	1.94	1670.87	3.84	1.91	1594.87	3.83	1.90	1507.75	3.97	1.98
2500	1744.15	3.84	1.91	1670.35	3.80	1.89	1590.99	3.78	1.88	1505.04	3.91	1.95
3000	1764.47	3.83	1.91	1681.34	3.78	1.88	1601.19	3.76	1.87	1503.22	3.89	1.94
Aircraft Price (1973$)	$ 18,134,000			$ 18,286,000			$ 18,412,000			$ 18,682,000		

TABLE A-116

N80-2.30 INDIRECT OPERATING COSTS VS DISTANCE

DISTANCE (NM)	DOC 15¢			DOC 30¢			DOC 60¢			MINIMUM FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	2872.89	17.24	8.58	2863.37	17.18	8.55	2852.94	17.12	8.52	2863.37	17.18	8.55
250	2105.93	7.58	3.77	2099.48	7.56	3.76	2073.00	7.55	3.75	2079.78	7.57	3.77
500	1558.36	4.36	2.17	1544.88	4.36	2.17	1531.45	4.35	2.16	1463.53	4.42	2.20
750	1304.19	3.29	1.64	1280.20	3.29	1.64	1242.98	3.31	1.65	1181.58	3.39	1.69
1,000	1144.23	2.76	1.37	1121.29	2.77	1.38	1090.23	2.73	1.39	1031.60	2.87	1.43
1,500	969.25	2.23	1.11	950.49	2.24	1.12	922.57	2.27	1.13	874.69	2.34	1.17
2,000	880.38	1.96	.97	860.13	1.98	.98	835.74	2.01	1.00	790.90	2.08	1.04
2,500	819.56	1.80	.90	802.02	1.82	.91	779.26	1.85	.92	740.58	1.93	.96
3,000	780.56	1.70	.84	763.88	1.72	.85	742.86	1.75	.87	704.37	1.82	.91

TABLE A-117

N80-4.30 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 15¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	1992.11	10.96	2.71	1997.03	10.98	2.72	2016.25	11.09	2.75	2136.97	11.75	2.91
250	1802.03	6.34	1.57	1784.49	6.35	1.57	1771.25	6.52	1.61	1850.60	6.88	1.70
500	1700.58	4.69	1.16	1655.29	4.77	1.18	1647.08	4.81	1.19	1687.09	5.23	1.30
750	1644.07	4.17	1.03	1601.16	4.21	1.04	1582.04	4.28	1.06	1611.89	4.69	1.16
1000	1614.62	3.91	.97	1569.09	3.92	.97	1551.26	3.99	.99	1572.63	4.40	1.09
1500	1584.90	3.63	.90	1536.32	3.67	.91	1517.95	3.71	.92	1531.03	4.13	1.02
2000	1570.82	3.52	.87	1523.22	3.53	.87	1502.66	3.58	.89	1512.04	3.99	.99
2500	1565.23	3.44	.85	1515.85	3.45	.85	1492.59	3.50	.87	1501.09	3.91	.97
3000	1566.37	3.40	.84	1512.35	3.42	.85	1492.04	3.46	.86	1495.58	3.87	.96
Aircraft Price (1973 $)	$ 28,012,000			$ 28,080,000			$ 28,494,000			$ 30,218,000		

TABLE A-118

N80-4.30 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 30¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	2268.91	12.48	3.09	2273.82	12.51	3.09	2293.05	12.61	3.12	2413.77	13.28	3.29
250	2107.33	7.42	1.84	2076.29	7.39	1.83	2048.67	7.54	1.87	2122.63	7.90	1.96
500	2036.40	5.62	1.39	1958.46	5.64	1.39	1935.36	5.65	1.40	1958.63	6.07	1.50
750	1986.96	5.03	1.25	1911.41	5.02	1.24	1869.89	5.06	1.25	1878.90	5.46	1.35
1000	1964.32	4.75	1.18	1882.52	4.71	1.17	1843.08	4.74	1.17	1838.89	5.15	1.28
1500	1944.15	4.46	1.10	1856.50	4.43	1.10	1815.64	4.44	1.10	1797.48	4.85	1.20
2000	1937.62	4.34	1.07	1851.06	4.29	1.06	1806.03	4.30	1.06	1781.29	4.70	1.16
2500	1939.72	4.27	1.06	1849.51	4.21	1.04	1799.24	4.22	1.05	1773.04	4.62	1.15
3000	1951.11	4.24	1.05	1851.76	4.19	1.04	1807.09	4.19	1.04	1771.38	4.59	1.14
Aircraft Price (1973 $)	$ 28,012,000			$ 28,080,000			$ 28,494,000			$ 30,218,000		

TABLE A-119

N80-4.30 DIRECT OPERATING COSTS VS DISTANCE

FUEL PRICE = 60¢/GALLON

Distance (NM)	$DOC_{15¢}$			$DOC_{30¢}$			$DOC_{60¢}$			MIN FUEL		
	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM	$/Hr	$/NM	¢/ASNM
100	2822.51	15.52	3.84	2827.42	15.55	3.85	2846.64	15.66	3.88	2967.36	16.32	4.04
250	2717.91	9.57	2.37	2659.89	9.47	2.34	2603.50	9.58	2.37	2666.68	9.92	2.46
500	2708.04	7.47	1.85	2564.80	7.39	1.83	2511.93	7.33	1.82	2501.73	7.76	1.92
750	2672.74	6.77	1.68	2531.92	6.65	1.65	2445.58	6.62	1.64	2412.93	7.01	1.74
1000	2663.72	6.45	1.60	2509.39	6.27	1.55	2426.74	6.24	1.54	2371.40	6.64	1.64
1500	2662.65	6.11	1.51	2496.88	5.96	1.48	2411.03	5.90	1.46	2330.37	6.29	1.56
2000	2671.23	5.98	1.48	2506.75	5.80	1.44	2412.76	5.74	1.42	2319.79	6.12	1.52
2500	2688.71	5.92	1.46	2516.82	5.73	1.42	2412.52	5.66	1.40	2316.94	6.04	1.50
3000	2720.60	5.91	1.46	2530.57	5.72	1.42	2437.20	5.65	1.40	2322.98	6.02	1.49
Aircraft Price (1973$)	$ 28,012,000			$ 28,080,000			$ 28,494,000			$ 30,218,000		